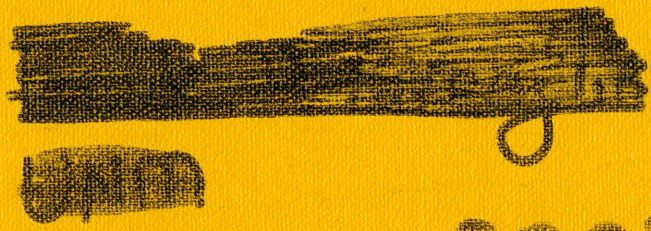
2003

Pazzaglia Field Notebook: Summer - Fall, 2003; Italy 2 and Crete Fieldwork

Frank J. Pazzaglia

SOKKIA™

Lehigh TRANSIT FIELD BOOK



Summer – Fall, 2003 →

Italy 2 +

Crete

No. 8152-00

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Day 16, Sunday June 8, 2003

HOT

ALL TREAD ELEV. UNLESS INDICATED

★ LAST DAY of surveying IN Terrace POINTS
0.9m Rover elev ; Reg elev for BASE.

- 08JUN FS1 QT6, ETRUSCAN RUINS @ MARGABOTTO
- 08JUN FS2 QT7, ETRUSCAN RUINS. The NECROPOLIS is dug INTO The colluvial APRON btwn QT6 and QT7.
- 08JUN FS3 QT5, CALANCHE TERRACE (STRATH downstream). I'm more convinced as ever that there is a FAULT here. If I had TO guess... THRUST. The NOSE of QT5 IS CUT right off, clasts just above the STRATH are rotated... imbricated vertically.

  PHOTOS 2→33-36 of FRACTURE PATTERNS & KNICKPOINTS IN The river. PHOTO 2-37 of The supposed fault.

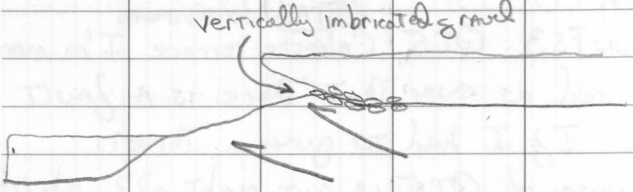
- 08JUN FS4 QT5 offset... or QT6 INSET AT The STRATH (→STRATH.) of lower CALANCHE TERRACE. All of my yR 2000 observations were right on... I really Think There is a fault btwn the two nothing obvious to date.
- 08JUN FS5 QT5 CALANCHE upstream (→STRATH) Wow! got TO IT VIA A landslide

SUBTRACT 0.5m TO get actual STRATH elev.

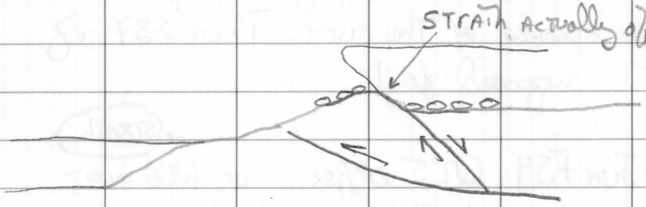
There remain a couple of possibilities for the "Calaveche Terrace fault"

(1) No fault

(2) A series of Thrust or reverse faults



(3) A Thrust fault with small Antithetic normal fault



(4) A normal fault dipping anyway you like!

I prefer (3)

UN levantino

08JUN FS6 Tread of Campi QT5; experiment to determine it's dip... This is the upstream point

08JUN FS7 downstream tread of Campi QT5

08 JUN FS8 QT4 Via Canovella.

08 JUN FS9 QT6 @ the school parking lot near the town of Cipollone

08JUN FS10 QT4 ... right on the scarp edge headed down to QT5 Ca'

08 JUN FS 11 QT7? QT6 @ Fontana Acqua RR crossing.

08 JUN FS 12 QT6 Spertcano

(*) All of these terraces on the east side of the river in the Marzabotto Area are perfect for soils.

08 JUN FS13 QT5 "Spertcano, on the way to Monte Sole

Day 18, Tuesday June 10, 2003

In Gattaiolana w/ Mauro + Pierluigi, yesterday, Day 17 was an "office day". Took forever to mail off the instruments. We did ultimately find a FedEx courier.

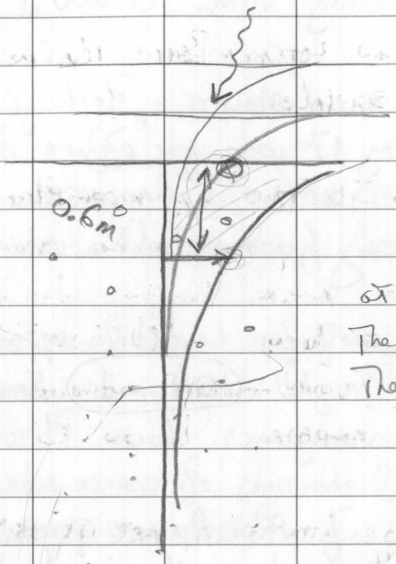
STOP 1. Road cut for Landslide repair - Frascone (Fornaci di Barga.) (10 Jun 1.) Sampled for burial cosmogenics. Lower Pliocene beds ... small channels of coarse subangular gravel + sand of Alpi Apuane provenance interbedded with thicker sandy overbank + pr bars loaded with organics, including wood. It is dark gry in color. Beds are vertical.

Frascone C1. - "e. Pliocene" deposits at road level, buried by about 16 m of deposit. 4m below the strath of overlying Pleistocene terrace deposits.

C2 basal alluvium of overlying terrace.

C3 1.0m below tread - I think this is a buried soil. - 5YR colors, nice peds.

C4 Top of terrace tread. in a sandy soil - it is QT7-like, maybe more like QT6 probably too fine grained



Sampling strategy for surface samples. One at the "undisturbed top" the other 1m below the surface.

STOP 2. Upper Pleistocene sediments of Barja fan - 100m thick valley fill. Near head of fan 100% Mocino clasts of eastern provenance. Typical alluvial fan debris flows + fluvial facies.

Loppia C1. 10JUN 2 sample taken ~ 15m from surface

Loppia C2 many, unknown meters below the surface 10 JUN 3 "lower Pliocene" deposits.

STOP 3. middle of upper Pliocene deposits. Loppia C3. On switchback

road cut between Loppia + Barga 10JUN4
~ 6m below surface.

STOP 4. Near the top of upper Pliocene deposits, across from nameless church on road to Barga. Sample taken from 4m below surface. 10JUN5
Almost all well rounded metamorphics here including marble. Loppia C4

STOP 5. Barga Fan - highest deposit - QT1. Alt Maccinio Fm. Sits unconformably on the Pliocene gravels which contain metamorphics. If correct, this QT1 represents a filling event of late Pleist age that buried a paleotopography with at least 100 m of relief.
Sampled the base of the deposit, 10 m below the surface.
Loppia C5. 10JUN6.

STOP 6 Barga Fan STADIO C1
10JUN7. QT3- looking soil atop T_2 - largest alluvial fan surface.
STADIO C1 56 cm - mixed zone below surface
C2 126 cm - in place

We must be very careful here... The surface is flat, but stratigraphy reveals cut + fill deposits. Soils + cosmogenics could be very complicated across these fan surfaces.

STOP 7. Mt. Peppoli - upland gravels btwn Castelnuova + Barga.

most of these gravels are out of place. There are alot of potato stones in the fields. Without a trench at the very top of the hill, it will be virtually impossible to collect a meaningful sample to date

HOT

DAY 19, WEDNESDAY JUNE 11, 2003

* IN THE SMALL TOWN OF OLIVOLA.

AULLA - OLIVOLA BASIN - MORE OR LESS THE SAME STRATIGRAPHY AS BARGA - CASTELNUOVO BASIN. PLIOCENE TO EARLY PLEIST. APUANE PROVENANCE DEPOSITS, INCISED, THEN BURIED + INSET BY MAGNO PROVENANCE ALLUVIAL FANS FROM THE NE.

- WHY NOT SEVRAL ALLUVIAL FANS HERE? ONLY A LATE PLEIST. FAN.
  (1) RECENT UPLIFT + PRODUCTION OF ACCOMMODATION SPACE
  (2) OLDER ONES NOT PRESERVED. - ALL RIPPED OUT.

- THERE IS A FAMOUS L. PLIOCENE FAUNA HERE.

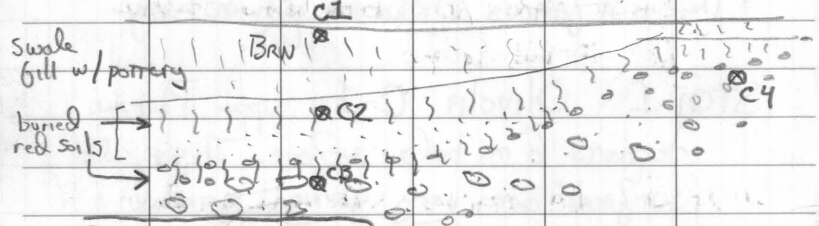
STOP 1 OLIVOLA C-1. UPPER PLIOCENE DEPOSITS 6 m BELOW SURFACE. THIS + ALL "SURFACES" ARE VERY YOUNG. MATERIAL HAS EXPERIENCED DEEP BURIAL. 11 JUN 1 PHOTOS 3-3, 3-4 OF THE ALLUVIAL FANS

② IT IS DIFFICULT TO ACCEPT 100 m OF INCISION IN 10 Ka W/O ANY EVIDENCE OF OLDER INCISION.

STOP 2 Villa Francian land mammal
Type locality. Olivola C-2 11 Jun 2
coarse sandy gravel in the Pliocene
beds, just above fossiliferous zone.

STOP 3 La Bifolca 11 Jun 3
Great! exposure of FAN gravels!
They look middle Pleistocene to me....
These guys think they are 10 ka.

The gravels look like the Mahnsville deposits,
really weathered, saprolitized.



Photos 3-5, 6, 7.

If these turn out to be middle Pleist., it explains
the incision better.

4 samples - C1 - C4, see sketch for location
C5 ~6 m below surface

C1	0 m
C2	2.04 m
C3	2.95 m
C4	1 m

My eye sees several buried soils. I see A very complex, polygenetic surface developed in a deposit of middle Pleist. Age

STOP 4 Pontemoli AREA → Case Ratti

This is the next BASIN North... supposedly younger (early Pleistocene). We are sampling

Case Ratti C1 upper Pliocene / lower Pleist. gravel

There are 3 fan gravels + associated surfaces
This STOP is at the middle one (in my)

Case Ratti C2 - Terrace gravels. 11 Jun 4
Sample taken from 6 m below surface for burial dating.

STOP 5 La Foce (The river mouth or "saddle")

C1 highest Terrace gravels 6 m below the surface. Here and at the last STOP, the deposits are relatively unweathered with the True surface exposures at STOP 3
11 Jun 5.

STOP 6 LA FORNACE (Brick factory)
Lowest Pontremoli Terrace. - virtually NO soil - Bw at best

- LA FORNACE C1 3.5 cm below surface in the mixed zone
- LA FORNACE C2 65cm in stratified gravel; Looks Holocene in age... supposedly yielded a late Pleistocene or e. Holocene fossil assemblage.

PHOTO 3-8. 11 JUN 6

(A) STOP 7 FILATTERRA - Late Pleist. Alluvial Fan surface. Two samples C1 in mixed zone, C2 ~ 1m down. Soil here actually looks late Pleistocene → v. much like QT5... There is 50m of incision below this to the valley bottom
C1 30 cm from surface in mixed zone
C2 1m below surface
11 JUN 7

* When cut was fresh soil was redder... clasts not nearly as thoroughly saprolitized as STOP 3.

UPDATE ON GPS WAYPOINTS

11 JUN 7	0574622	4909745	219 m
11 JUN 6	0569067	4914695	278 m
11 JUN 5	0568032	4913696	455 m
11 JUN 4	0568573	4914636	359 m
11 JUN 3	0578722	4897774	140 m
11 JUN 2	0582076	4897828	239 m
11 JUN 1	0582004	4897913	220 m
10 JUN 8	0614668	4884215	559 m
10 JUN 7	0617571	4880370	293 m
10 JUN 6	0619757	4880946	385 m
10 JUN 5	0619357	4879917	279 m
10 JUN 4	0619399	4879376	191 m
10 JUN 3	0619544	4879150	195 m
10 JUN 2	0619911	4879715	251 m
10 JUN 1	0616879	4879138	159 m
A10RBRDG, END of 05JUN survey	0678840	4917573	79
FONT ACC, Fontana Access	0678046	4916191	83
FONT FLTS, Faults+knickpts S of Fontana	0677485	4916029	93
RRBRDG2 Railroad Brdg downstream of Lama di Reno	0677062	4915480	86m
SETTACONF Confluence w/ Setta	0678724	4917173	68
04 JUN QT1I	0678738	4921504	279 m
04JUN QT3S	0679637	4921387	161 m

04	JUN	QT4s	0680129	4921471	97m
04	JUN	QT4t	0680058	4921520	90
04	JUN	QT5s	0680244	4921455	99m
04	JUN	QT5t	0680202	4921470	107m
04	JUN	QT6s	0680351	4921055	98m
04	JUN	QT6t	0680117	4921041	110m
04	JUN	QT7b	0680904	4920987	43m
04	JUN	QT8b	0681157	4920961	33m
07	JUN	FS1	0681628	4927054	29m
07	JUN	FS10	0680862	4920363	84m
07	JUN	FS11	0680868	4920322	87
07	JUN	FS12	0681086	4920170	95
07	JUN	FS13	0681035	4920579	56
07	JUN	FS14	0681091	4920600	96
07	JUN	FS15	0680570	4920349	96
07	JUN	FS16	0680437	4919311	84
07	JUN	FS17	0679530	4918634	107
07	JUN	FS18	0679401	4920662	182
07	JUN	FS2	0681787	4926641	71
07	JUN	FS3	0681320	4920959	68
07	JUN	FS4	0681090	4921397	82
07	JUN	FS5	0680967	4921158	73
07	JUN	FS6	0680805	4920677	83
07	JUN	FS7	0680747	4920645	82
07	JUN	FS8	0680951	4920498	63
07	JUN	FS9	0680960	4920166	79

08 JUN FS1	0675764	4911454	123	
08 JUN FS10	0677254	4915215	140	
08 JUN FS11	0678047	4916480	115	
08 JUN FS12	0674720	4910614	155	
08 JUN FS13	0674529	4910378	179	
08 JUN FS2	0675847	4911380	144	
08 JUN FS3	0676507	4911789	161	
08 JUN FS4	0676422	4911940	143	
08 JUN FS5	0676587	4911534	168	
08 JUN FS6	0676283	4912173	153	
08 JUN FS7	0676285	4912332	147	
08 JUN FS8	0676421	4912639	167	
08 JUN FS9	0676328	4914293	133	
12 JUN 1	0530816	4908170	618	mT. S. GIACOMO
12 JUN 2	0528776	4905475	35	
12 JUN 3	0530116	4904310	26	
15 JUN 1	0342732	4810579	449	33T
15 JUN 2	0344716	4795919	1083	m. s. ↓ VICINO
QI76 S1	0680586	4920518	92m	

33T

Day 20, Thursday, June 12, 2003

In Liguria. Mt. San Giacomo at Lavagna. (12 Jun 1)

Entella river - builds a nice delta here at the coast - This river has nice terraces, never been studied.

Photos 3-10, 3-13 panorama of coastal area looking from south to north over Portofino.

Some "notches" on the Portofino peninsula at 7m above sea level.

From French border to Genoa the Pliocene is decreasing in elev. Also... The stage 6 terrace is not uplifted. At our present location it may be @ 30m, then it "falls" again towards La Spezia. The Tuscan Islands have some "terraces" that may be IS 6... preserved at sea level.

STOP 2 Via Panoramica - marine terrace @ Lavagna, S(E) of town. 12 Jun 2

All of the rock types here, in the deposit are from the local basin ... no limestone

Similar composition to the Holocene beach, similar grain size.

This really looks like a beach deposit, low-angle x-strats, disk-like pebbles 1-2 m thick. Very weathered, many saprolitized clasts of ss.

- Age of 139 ± 11 OSL age from weathered sands at base of deposit.
- There may be more than one terrace here
- The weathering + soil is consistent with something at least stage 4 or older.

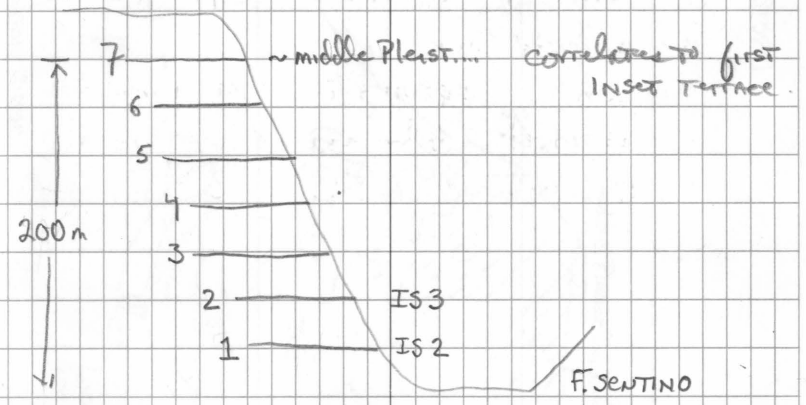
STOP 3. - on main coastal road... adjacent to cemetary. possible other terrace levels here.

~22 m ... exposures are too overworked & destroyed. When exposed.... it was supposedly "less weathered" 12 Jun 3

Days 21 + 22 Friday + Saturday,
June 13 + 14, 2003 both days

Friday was mostly a travel day, following a meeting with Frederici ... went well. Then it was 5 hrs from Pisa to Coldigioco.

Saturday was spent in the cave at Frassassi - Fantastic. One ascent, 2 descents with ropes and 2 very tight crawls! Level 2 is the tourist level... we went between levels 2 + 3. Level 2 is thought to be the IS 6 level.



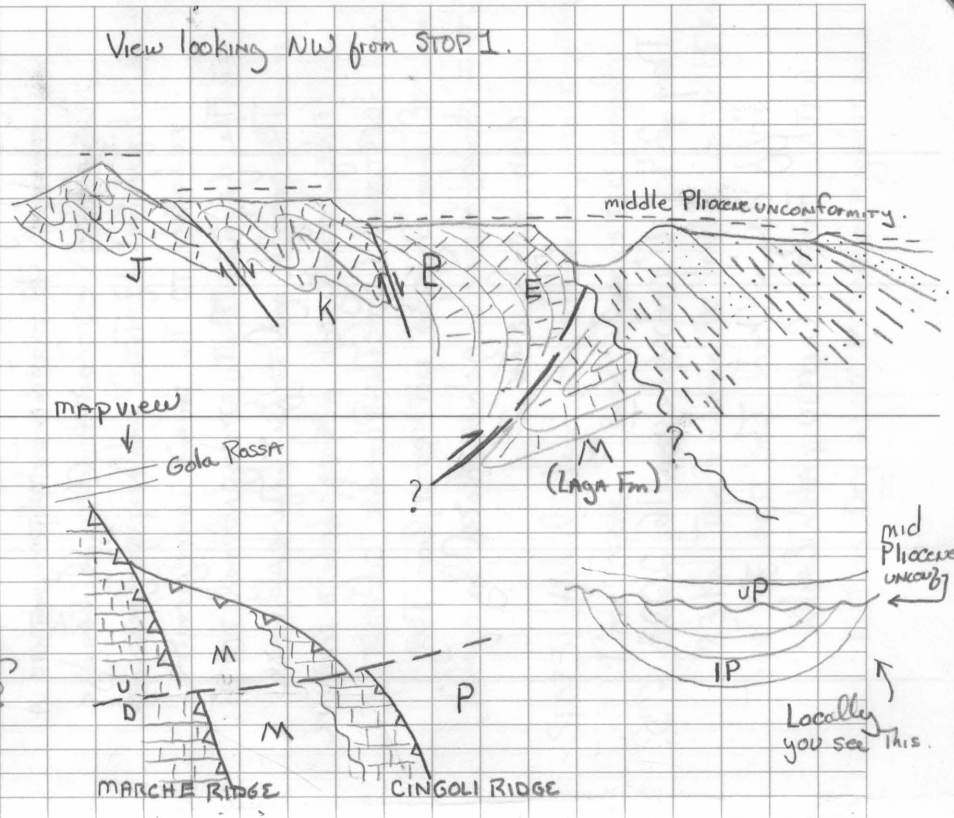
The upper TWO MOST CAVE levels have a dominate EAST WEST direction.... following Mesozoic Age THRUST? FAULTS.

The lower CAVE levels all HAVE a NE ORIENTATION... following The gorges + possibly ACTIVE NORMAL faults developed normal to The strike of The belt.

Day 23 Sunday, June 15, 2003

STOP 1 Sasso-Castellaro - overview of Planation surface. 15th Jun 1

- Almost here, the unconformity cutting the lower Pliocene is traceable to the carbonate ridge



STOP 2 S flank of MT. S. VICINO
15 JUN 2 MT. CALFANITO

- High level erosion surface, cut across Limestone. (dippy)
- Residual soils ... meters of chert.
- No physical connection to Pliocene rocks... but seems to project to a surface cut atop Cingoli Ridge
- how much of these modern surfaces are related to the parent unconformities.
- The faults that strike normal to the orogen and offset the carbonate ridges really do not appear to continue eastward into the Pliocene sediments. Either they do not exist, or they somehow are accomodated by folds, distributed shear.

DAY 24, MONDAY, JUNE 16, 2003

"off day". Used the time to visit with FAUSTO, CERRETO, AND EMILIA.

DAY 25, TUESDAY JUNE 17, 2003 EOD:

STOP 1 CASE ORFEI greze-ite. 17JUN 1

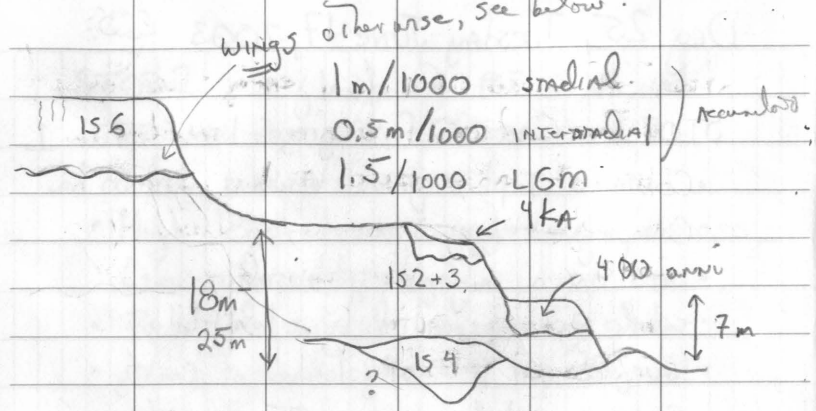
- CONTAINS TEPHRA from VESUVIUS 28-35 ka CAMPANIAN IGNIMBRITE.
- SITS ON a SANGAMON PALEOSOL
- whole section is TILTED by a landslide.
- surface soil is mostly leached of $CaCO_3$
- SANGAMON soil has a STAGE III calcic horizon beneath a yellowish-red Bs / Bt horizon
- GET THE papers by Cremaschi ↘ very dark red Bt

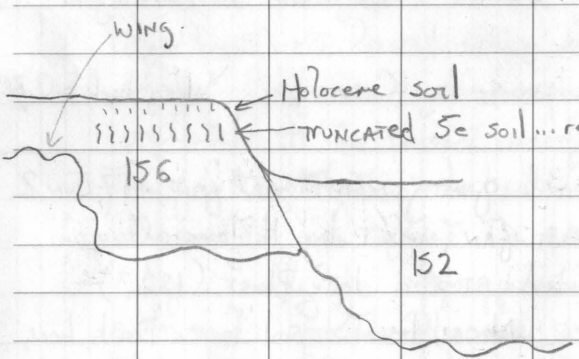
STOP 2 Gravel quarry in Alluvial fan 17 JUN 2

LATE PLEIST FAN, INSET by HOLOCENE alluvium and graded ATOP A late PLEIST (152?) TERRACE. Nice, leached soil here. Dark brn, Bt, good STRUCTURE .. location IN A TOESLOPE has ALMOST CERTAINLY enhanced development.

STOP 3 fluvial deposits, ALLUVIUM, nice exposure CASE PEZZE. BASE of deposit is meandering stream, pt. bars, overbank... 36 ka up TO 23 ka. Then A change TO braided up TO 15 ka

- F. ESINO
- ~12 m THICK
- 154 is DRY + NO INCISION or pedogenesis





STOP 4 Active gravel pit S of Cerreto d'esi.

STAGE 6 gravels + 5e soil exposed.

- some weak buried soils in the alluvium
- looks mostly braided
- ~ 6-8m exposed., sampled at 8m below surf.
- soil is truncated, preserved in sediment pots + wedges ... NOT periglacial
- Colferraio quarry C1 17 JUN 4

STOP 5 SAN MARTINO, early Pleist. deposits in the Colfiorito basin... incredible residual soil - just chert left from a presumably carbonate rich deposit (fan, alluvium...) still stratified. How? A 400 ka tephra was dated here.
17 JUN 5 Photo. 3-33
30+ m thick... how to date one sample this

STOP 6 Ponte di Crisplero 17 JUN 6

→ IS 2+3 slope deposits / Alluvial fan
IS 4. loess w/ U-Th date on carbonate nodule 60 ka.
IS 5 soil
IS 6 Alluvium ← Neanderthal tools
weathered carbonate bedrock.

many buried soils, high resolution slope wash stratigraphy.

STOP 7 Madonna de Lavorina/Matelica Hill
Highest, oldest Terrace in the Esino basin.
4m below surface. This terrace

has a provenance of more "Scalia" cover rocks rather than underlying, older carbonate

Sample F.1 Metalleca

17 JUN 7

DAY 26, WEDNESDAY, JUNE 18, 2003

- GRAN SASSO, CAMPO IMPERATORE
- Asergi, Hotels located here

TRANSUMANSA - seasonal migration of shepards through this region

TRATUTTO - The paths of the TRANSUMANSA

- GREAT! NORMAL FAULT + BASINS + FANS + MORAINES ON the south flank of GRAN SASSO, CAMPO IMPERATORE
- GREAT! INCISED MEANDERS.
- PASS at VADO di SOLE
- RIGOPIANO - gravels here are a well cemented calcirudite. A few PECTEN + GASTROPOD remains karstified. Virtually impossible to sample for DATTYL... but there are a few NON-CARBONATE CLAST we might sample for PETE REINERS.

Beds appear to be striking 310°, SW dip between 10 and 45°.

18JUN 1. Sample RIGOPIANO 1 - surface sample to obtain minimum age of exposed surface. As we did for MT. CIMONE. (R1, TOP) written on sample.

18JUN 2 Location of SANDY sample for PETE REINERS

R2

STOP 2 Heterolithic gravels of MT. Coppe exposed on road the continues north and west away from Rigopiano.

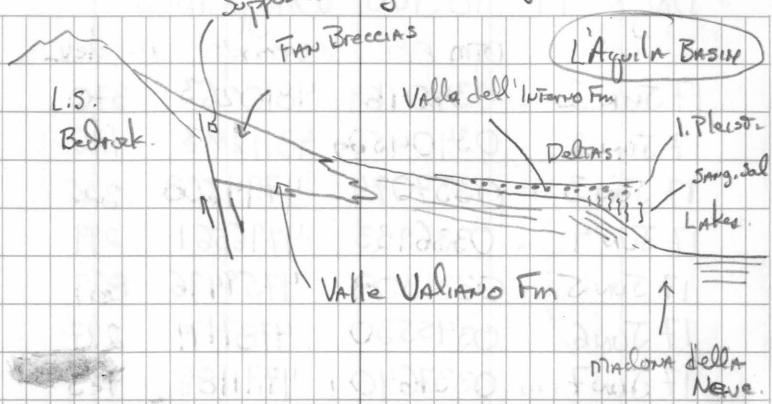
We are sampling SS + granites (if we find them) for Thermochron.

18JUN 3 MC1 - base of gravel
MC2 - basal S.S.

These gravels are much better sorted than the Rigopiano Fm. There is a pebbly SS ~20cm thick right on the unconformity. Good for Thermochron, bad for cosmogenics... was likely exposed on the slope for a long time.

- Santo Stefano - cut town w/ accomodations + 1 restaurant outside of town.

STOP 3 Barisciano, near L'Aquila.
Great! Fan Delta middle(?) early (?) Pleist. Age. Very well developed soil on top - Sangamon?
Material is a sandy gravel... all carbonate? maybe some quartz. B1.
18Jun 4
Sample is 10+m below the surface



STOP 4 18 JUN 5 Madonna della Neve
Barisciano B2 Tephra. Sampled for Ar-Ar. Maybe too fine grained.
Not weathered, not very much reworking
Mauro thinks this is late Pleist.

STOP 5 18 JUN 6 Popoli; Via
Yellow medium sand beneath a 420 ka Ash.
Mauro disputes the date
Sand is 4+ m below the surface, probably more as the surface has been modified.
P1 = sand Zona PEP
P2 = Tephra.

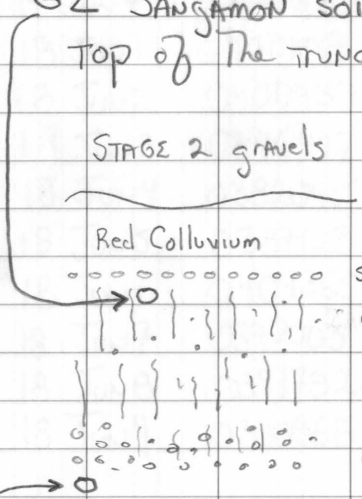
Days 17 - 18 Jun Waypoints

	UTM E	UTM N	elev
17 Jun 1	0340469	4810263	370
17 Jun 2	0340452	4811203	196
17 Jun 3	0337074	4794508	326
17 Jun 4	0336933	4796561	299
17 Jun 5	0331308	4759496	869
17 Jun 6	0345530	4787194	297
17 Jun 7	0337640	4791184	423
18 Jun 1	0400108	4698304	1100
18 Jun 2	0400430	4698325	1065
18 Jun 3	0396447	4701666	1130
18 Jun 4	0382045	4686004	870
18 Jun 5	0387123	4684073	821
18 Jun 6	0404365	4668215	285
18 Jun 7	0392003	4653149	852
18 Jun 8	0391782	4653306	839
18 Jun 9	0390868	4653798	817

STOP 6 FUCINO BASIN - PESCINA.
GIOVENCO VALLEY.

G1 Upper Plest.(?) gravels 8+ m below surface.
18 JUN 7, really NOT quartz rich....
surface highly disturbed, + locally cemented by CARBONATE.

G2 SANGAMON soil. As close to the top of the truncated profile as possible



G3 Way down in the IS 6 gravels in abandoned quarry. This facies is sandier - but again, packs a lot of quartz.
10+ m below surface. 18 JUN 9

Spring 2004

Italy Field Work

Day 1, Thursday, April 29, 2004

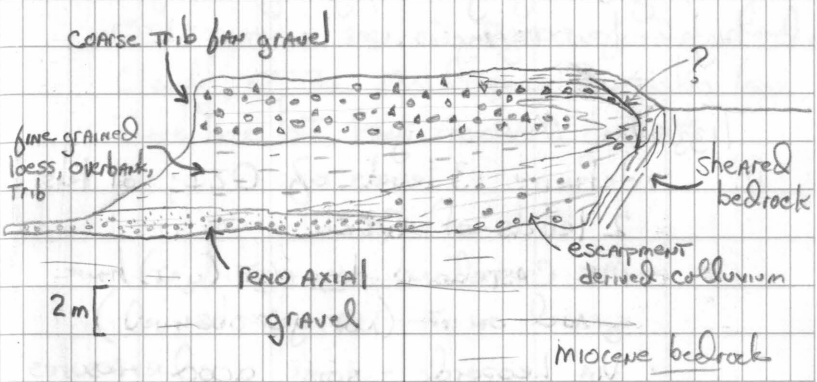
Beginning of 2004 Mapping Season. Il Cerro, Pian di Venola base. With James Cascone, working on his PhD project 1. Goal - work with the older terraces in Reno + surrounding region to determine uplift, incision, and rock deformation history.

Goals today - Mt. Sole, Etruscan Ruins, Pleist-Holocene terraces, evidence for faulting.

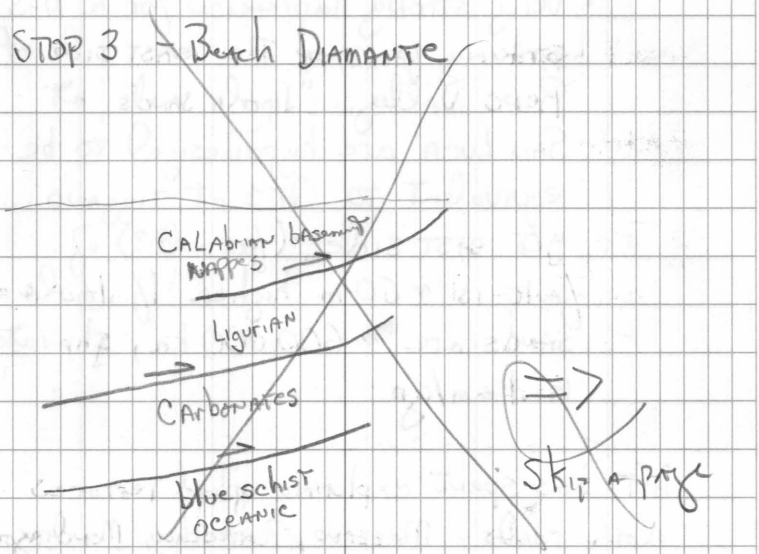
Il Poggio, Mt. Sole hike

- Very young looking - gray - charcoal, unlike the yellow of M-P deposits. Stratified, laminated sand, micaceous, carbonaceous. On narrow divide; no gravel.
  both fining up + coarsening up thin-med beds.
  No fossils ? possible windgap fluvial deposit?

MARZABOTTO Terraces – A "defining" observation.



- STOP 3 – Beach DIAMANTE



DAY 2 Friday, April 30th, 2004

Working our way through the valley - high + low terraces.

TIZZANO + MONASTERY.

- definite 3 levels of Qt1; at least 2 levels of Qt2.
- MT CASTELLANO does NOT (yet) have gravel on it (NOT yet observed)
- VIA Leopardi - some good exposures including a new house foundation
- Very STRONG impression for a N-S striking fault on the EAST side of Reno Valley. "Imola sands" at SAN LUCA are hypothesized to be equivalent to Qt1 at TIZZANO.... yet EAST side, (footwall?) of fault is ~60 m higher. If Imola SANDS are ~600,000 ka, slip rate is .1 mm/yr.

AFT was spent exploring upland terraces along roads - Mezzano, Pontecchio, Monpragon, Balsenda, and Moglio.

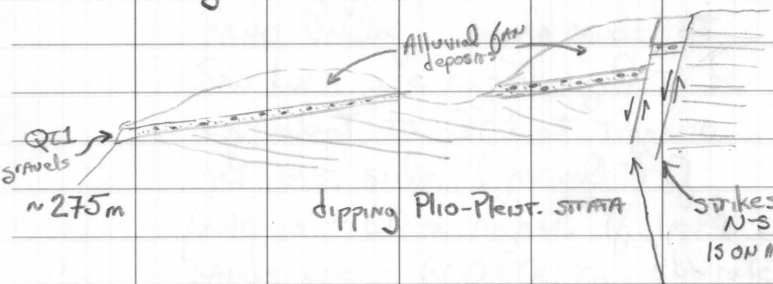
We've reconfirmed previously known Qt1 + Qt2 sites... but we've made progress on establishing the presence of the same 3 Qt1 terraces seen at Tigano, further inland. Clearly, at the Mondragon - Pontecchio loop, there are at least 2 Qt1 deposits.

Day 3, Saturday, May 1, 2004

Morning - driving w/ James
- Assembling geologic basemap, and transfer of data to field maps

Aft - we worked two roads - Mondragino and St. Antonio di Soppra, (e sotto). This second road is a real find - gravels exposed in road cuts, and very good views south across V. Mondragino to exposed gravels, unconformably overlying tilted Plio-Pleist. strata.

View looking SE.



cool

Day 4 Sunday, May 02 2004

With Vincenzo - mouth of The Zena just NE of Farnetto. GPS 04 02May01
Zone 32. 0691573 E 4924011 N

Great outcrop! Imola Sands (Sabbia gialla)

beautiful yellow beach sand

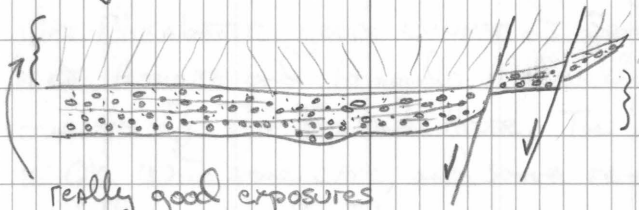
has Apennine clasts including black J chert, gabbro, fractured + recemented L.S.

has well rounded pebbles - longshore drift - The key rock type is a medium brown chert from Marche! (sometimes has forams

Photo.

Aft. w/Vincenzo, Missy has arrived. We worked the fine exposures on the south flank of Mondragino valley. - These are Accessed by Via Castello, center of Sasso Marconi.

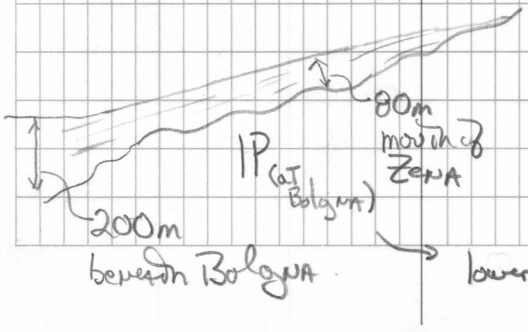
Essentially, what we recorded yesterday is correct. There is a fault. The big gully landslide is difficult to access, and is covered with landslide & vegetation, but....



really good exposures of post-terrace deposits - These are compositionally & texturally colluvium + alluvial fans - locally derived. They contain for example reworked mollusks from the Pliocene marine beds.
- Some buried soils - more red at base

Important information on stratigraphic ages from Vincenzo.

- Sabbia Gialle - 600,000 - 800,000 yrs old.
- All units in Piggyback basin are lower Pliocene.
- Sabbia Gialle is tilted on Avg ~ 15°



Day 5, Monday, May 03, 2004

Travel day. 2.75 hrs to Coldigioco from Il Certo. Weather has been very changable. Met Elisabetta, good dinner at Sandro's. met Assunta and Armando Marinelli - owners of the Frontale House. The house is Ok. With some care, and some rearranging, it will be fine for the year.

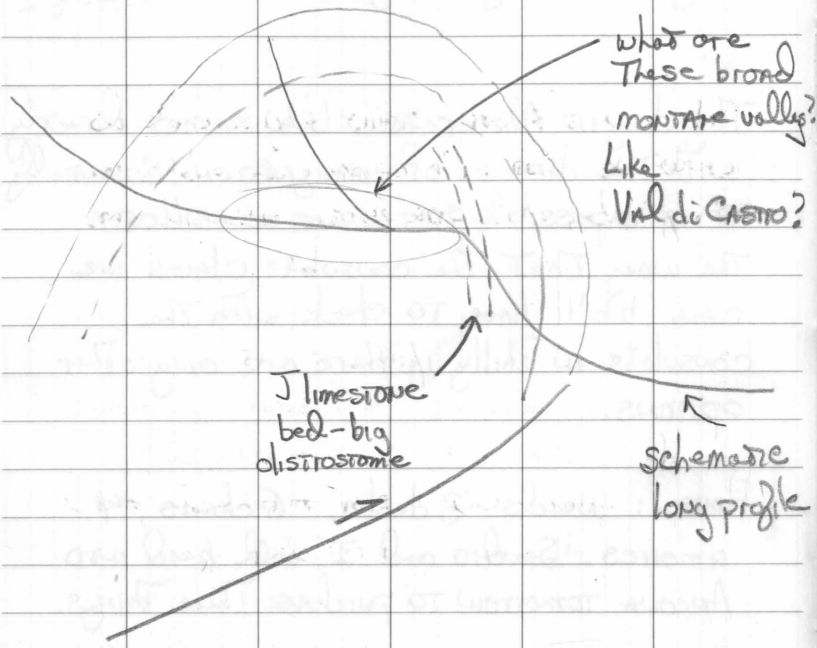
Day 6 Tuesday, May 04, 2004

The day in Macerata. We've met directly with the director of immigration. Essentially, it is impossible to receive a nullosta the way that the consulate claims we can. We'll have to check with the consulate in Philly if there are any other options.

House: needs 3 desks, ~6 chairs, ~4 armoires. Sandro and I will head into Ancona tomorrow to purchase these things.

Geology: Cingoli Ridge is cut by 2 transverse drainages - the Musone and a smaller (much) stream. It is unclear if the smaller stream is remnant of a capture, or if it is truly superimposed.

The east flank of the Mt. San Vicino ridge has a very interesting geomorphology, the origin of which is very unclear at the moment.


what are
These broad
mountain valleys?
Like
Val di Castro?
Limestone
bed - big
oolitostone
schematic
long profile

Day 7, Wednesday, May 5, 2004

Today was another travel day... back to Bologna. But, we also did a day in the field, Mt. Cornero, Ancona. The key observations made are:

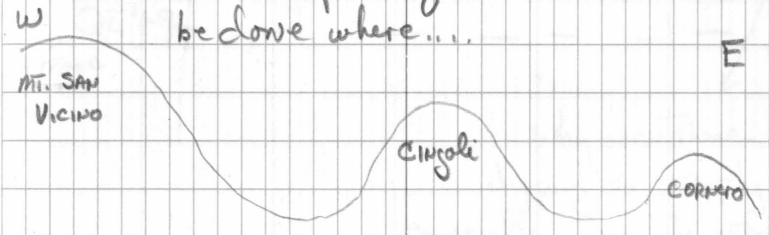
(1) Marine terrace are obscure, but possible in some areas.

(2) Mt. Cornero likely emerged as an island first; it is surrounded by upper-mid Pleist marine deposits, that appear to be dipping.

(3) Upper Pleist beds are essentially a conglom w/ angular pieces of mudstone & ss. Is this a Sabbia gialle equivalent? elev ~150-200m.

(4) mid Pleist beds are all to the south of Mt. Cornero. elev ~80-150m

(5) Can a space-for-time substitution be done where....



If all emergent at same time - they should have similar degrees of dissection. If not, they should less dissected towards Cornero.

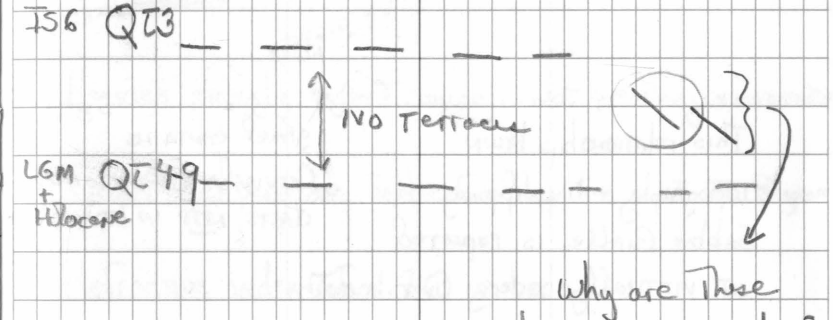
We visited deposits SW of Ancona on a hill ~200 m, location of large Airport radar facility - similar to, but not the same hill as one with huge radio antenna towers. These hills are mantled by the coquina deposit.

Carta Sismotettonica, 2003 (Regione E-R).
R. Pignone; 1:250,000

Day 8, Thursday May 6, 2004 cool

Field day with Paolo Severi, Darryl Granger. Two main stops Tizzano - Mt. Castellano and Via St. Antonio di sotto.

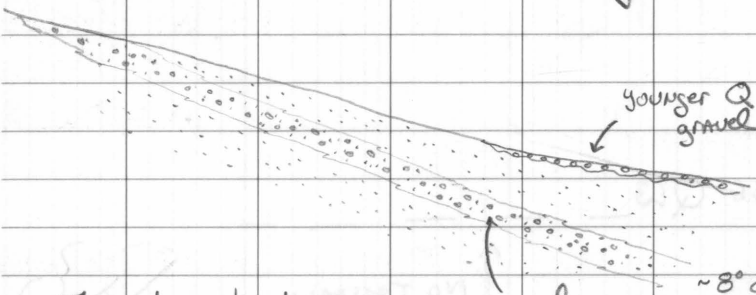
Tizzano - we discussed the possibility of Sabbie Gialle on the west flank of the mouth of the Reno. Paolo said this was his first interpretation, but then changed it - he was worried about the fact that it was "too coarse". But it is not very logical to do this



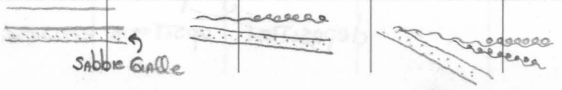
ST. ANTONIO di SOTTO + VIA CASTELLANO (SASSO MARCONI)
PAOLO was pretty CONVINCED of the FAULTED Qt1, he also agrees THAT THE TERRACE IS dipping downSTREAM ~ 4° ... THE river channel at THE SAME LOCATION IS ~ 1.5° DARYL will definitely SAMPLE here.

Aft - Along the T. LAVINO between ZOLA PREDOSA and RIVABELLA. There is a park, easily ACCESSIBLE from several points off of the MAIN ROAD (26 BO)

VIEW looking WEST



This relationship btwn TOPOGRAPHY + the dipping SABBIE GIALLE is repeated at virtually every river mouth



Day 9, Friday May 7, 2004 cool

Meeting in Bologna with Vincenzo, Gian Andrea, and Gian Zuffa.

Notes on Heavy Mineral Analysis of Q gravels

Apennines are devoid in pyroxenes + Amphiboles. and have no dolomite.

Maccinio - no staurolite, but rich in epidotes
Ligurian - contains staurolite
Epiligurian - A real mixed bag. - Epiligurian basins east + west of Secchia line are quite different

Feldspars in Pliocene are reworked out of Cervia + Maccinio.

Heavies strongly reflect source ... not weathering + maturation.

Cibin - expert on Sabbie Gialle, he is at The Register.

Refractive index of 1.70 is best.

DAY 10, SATURDAY, MAY 08, 2004

Rodney Chouka
Editor, Physical, Chemical & Earth Sci
ISI Thomson
3501 Market St
Philadelphia, PA 19104

COMPARE TO SCI

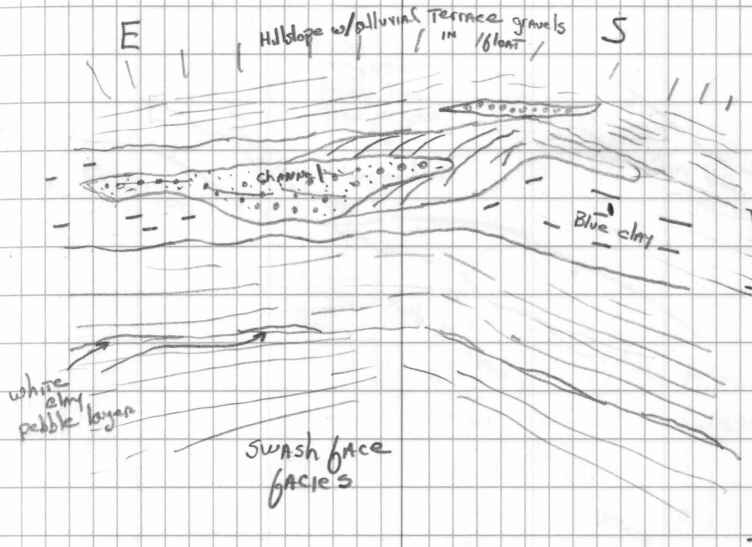
Geografia has a 30% rejection rate
similar to Earth Surface Processes & Rivers for Geom.

Purchase a book - MATTEO will do This, 30€
ARPA Emilia Romagna - climate of Regione, 1951-94

DAY 11 SUNDAY MAY 09, 2004 NICE

STATION 04 MAY 09_01 SABBIE GIALLE
AT LOIANO – 888 of VIA STANZANO ROAD –
ACROSS FROM WINERY ... look for gated road.

Great exposure – 2 samples
S04MAY09_01 – beach sand + pebbles
S04 MAY09_02 – blue clay (for pollen)



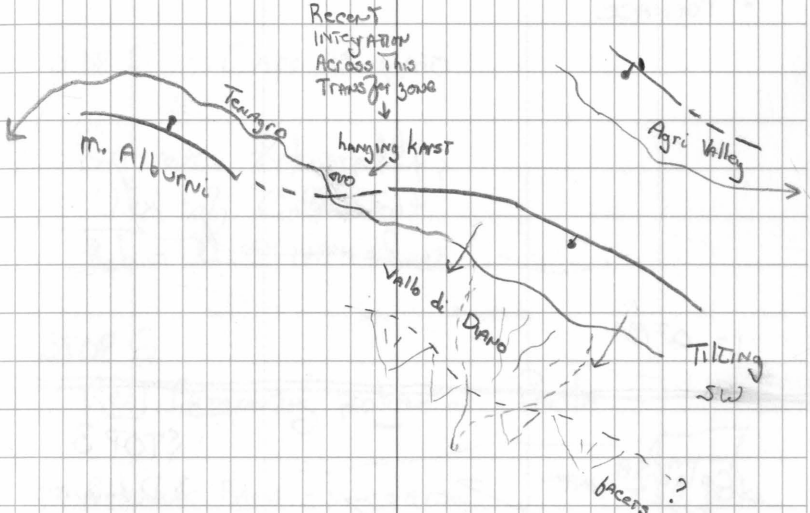
UTM LOCATION ZONE 32 0703497 E
4918951 N

RETREAT MEETING; SUMMER '04

DAY 1, SUNDAY, JUNE 27, 2004

Field TRIP for pre-RETREAT Conference.

- Overlook of VALLO di DIANO - ON THE RD between Vallo di DIANO AND Val di Agri, ABOVE THE TOWN OF A. LUCANA



- LUNCH at Agriturismo Vignolo, ON RD BETWEEN PATERNO AND MÁRSICO

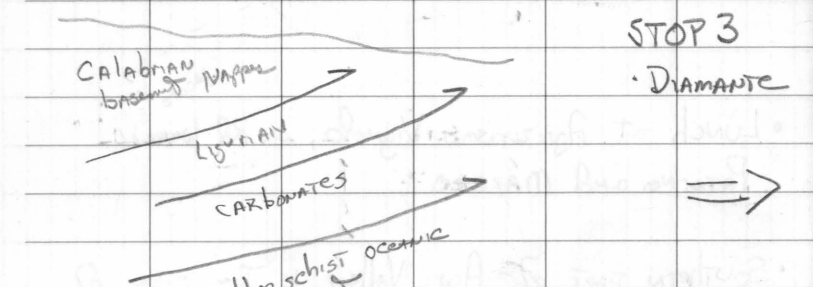
- SOUTHERN PART OF Agri Valley IS THE SITE OF THE 1857 "GIANT" EARTHQUAKE.

DAY 2 06/28/04 HOT

EVENING IN VILLA del MARE

- TERRACES IN THE VICINITY of Isola di DINO
  Very nice morphology, but a general lack of beach deposits; bedrock is CARBONATE; buried by ALLUVIAL deposits, + LANDSLIDE.

- FORNACE



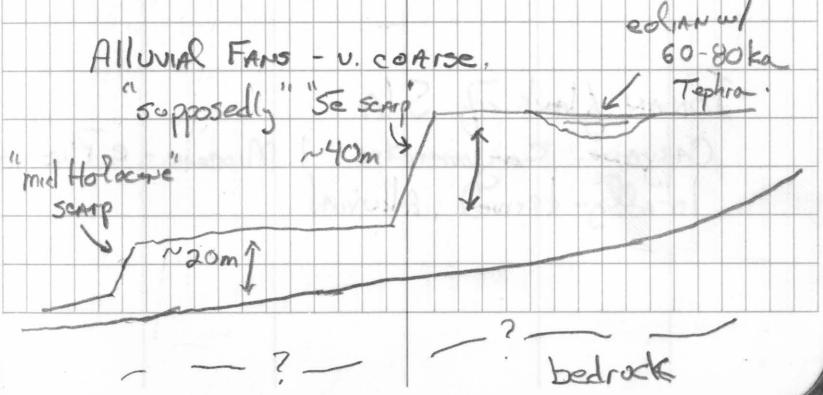
STOP 3
- DIAMANTE

- STOP 4 - LAISE, NEAR Belevedere Marittimo
- STOP 5 - Capo Bonifato.

GAETANO Robustelli.
Univ. of Calabria

- STOP 6

Real Interesting problem at Paola -



Day 3 06/29/04, Tuesday ☼

Morning lecture by Paolo Galli, Protezione Civile Nazionale, Servizio Sismic

- 1638, S. Sila (south) Catanzaro – cluster around S. Sila
- 1905 Between Catanzaro + Reggio
- 1783 Reggio Calabria
- 1908 Messina

→ Casno – 0.8 m offset; Lakes Fault
Colle delle Giumello, recurrace interval of ~1000 yrs.

Lago fault pressure ridge
0641666 UTM zone 33
4343541

Lidar (?) is a project for Karl.

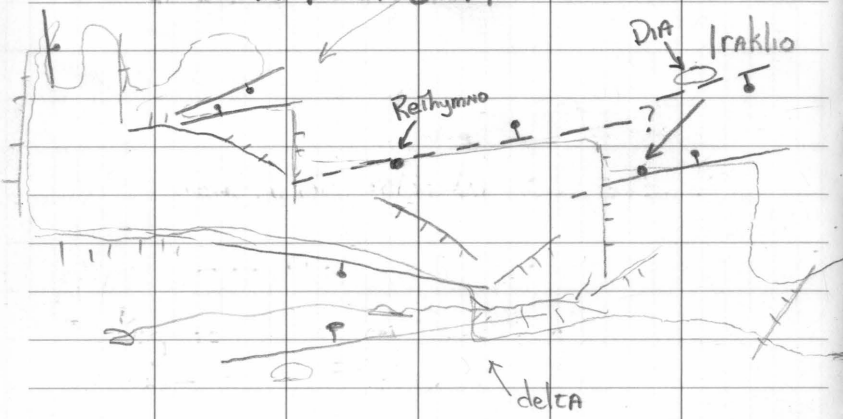
- Ionian flank of S. Sila
  Caruane Conglomerates l. Miocene – e Pliocene
  locally-derived; Alluvial

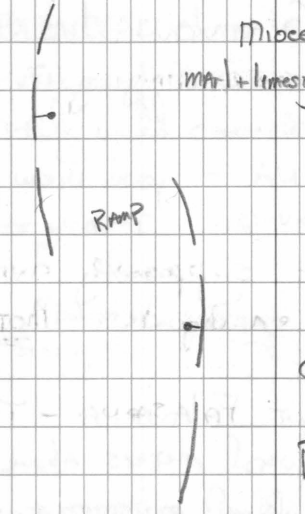
Tuesday, Wednesday, July 6-7, 2004

Greece, Crete, Hirakliyon
w/ Mark, Nicole, Karl, Kristen Anderson, Babbas.

Crete01 - Platencalc; Permian Fossils.
lower Plate, 30 km depth, not deformed.
355 0310954; 3917607
Rethymno - great sea side town west of Hirakliyon

Crete02, Lunch.; several terrace w/ marine deposits on top along the way.
ΑΚΡΗΜΙΟΣ. This is a Harbor of a NATO Navy base. Souda Bay
355 0239129 3928794





- Very good P-Q strat including terraces + fans in western Souda bay —
- TAYPONITHE → TAURONITIS, very thick, red, fluvial gravels, exposed in highway roadcut.

CRETE 03, West of Kolimbari

345 0750655; 3935437

- Peninsula of Gramvousa has very good marine terrace ringing it.
- Rd to Falasarna - good view of the W side of Gramvousa. Terrace + uplifted Gra[illegible]town - supposedly during the 350 AD earthquake. Photo
- CRETE04 Ancient Falasarna - The harbor is now several meters above sea level. On Road outcrops ± at the harbor is a dipping, thinly-bedded packstone-grainstone calcarenite, probably Pleistocene; can maybe be Sicilian (0.7Ma), is likely on the HW + FW of a normal fault.

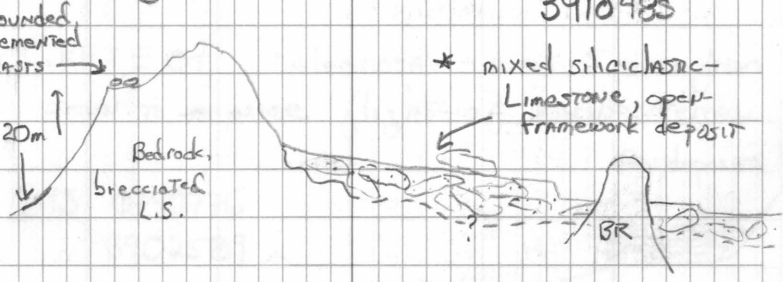
34S 0733022; 3932743

- CRETE05 Exposure of low-angle detachment on Western highway - covered by a Limestone breccia, with marble clasts. Maybe Q.... maybe a bench breccia.

34S 0734161; 3925341

- Big red-weathered, thick alluvial fan is exposed at Sfinari

• CRETE 06 Hrissoskalitissa. Marine Terrace & River Terrace – oldest one is really well cemented. 345 0730262 3910485



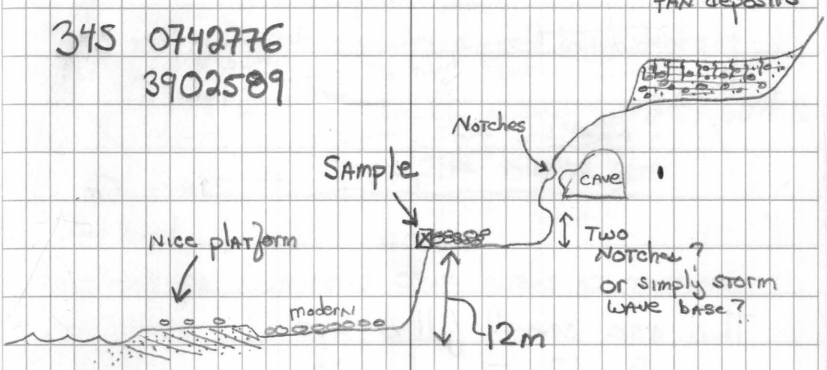
* Seems to be broken into large blocks, This is the place where There are supposed to have 7 Holocene Terraces, youngest on top. Rather, I do not see Terraces... The younger on top deposits are likely simply stratigraphically younger beds... of a distal fan delta.

Thursday July 8, 2004

Very windy This morning - unable to take The ferry or The small boat.

CRETE 07 Paleohora - walk 5 mins from town to a nice flight of marine terrace.

345 0742776
3902589



Sample is weathered shell material, interbedded with the coarse gravel.

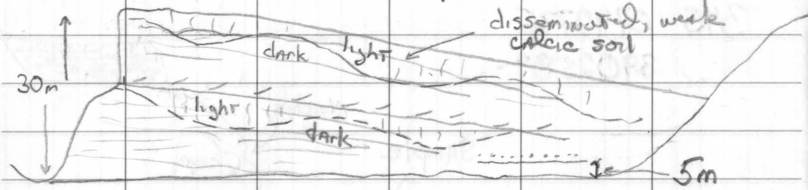
Bedrock is a limestone breccia.

Rest of the day was spent visiting the southern shore of town Paleohora and Sfakia.

Observation 1 - Some drainages, typically the smaller ones, have huge fans - colluvial to alluvial at the coast, along with thick alluvial fills in the valleys.

Big drainage west of Samaria - looking North

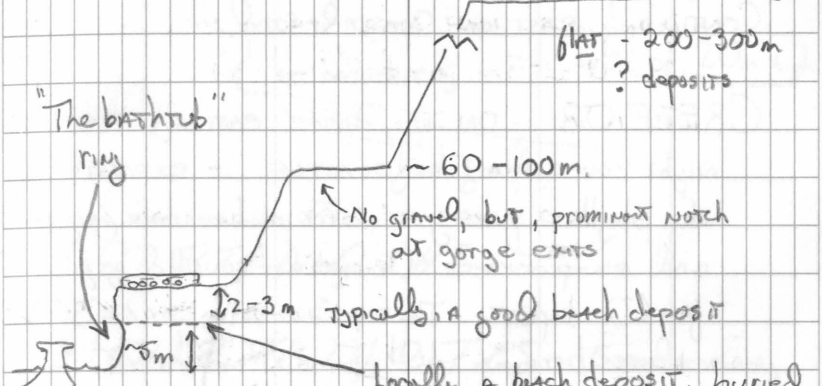
Tripiti



There are several fill deposits preserved in the canyon .... with flood-type rythmites - not lakes, but ponding.

Samaria Gorge - cemented, small falls, nothing like the gorge at Tripiti; however, homes < 200 yrs old have been recently buried + exhumed.

Observation 2 - MARINE TERRACE STRATIGRAPHY

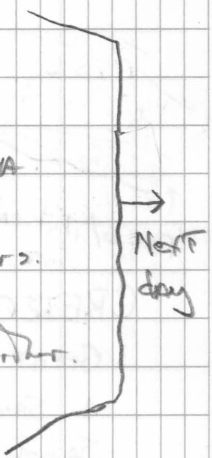


There are numerous cave levels at terrace levels.

The Mesara basin has

1) Pliocene matrix
2) Terraces - Kamilari area
3) Fans! Lots of them
4) big terraces on the big Rivers.

definitely a place to investigate further.

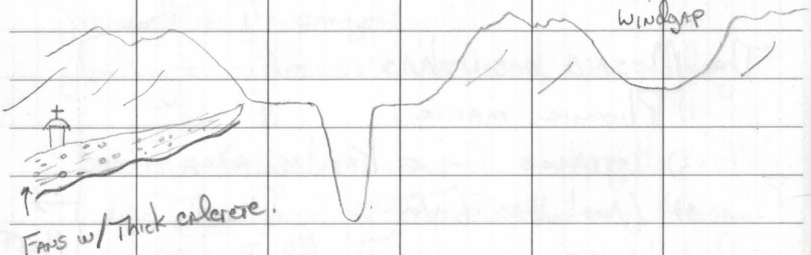


Friday, July 09, 2004 ☼ HOT

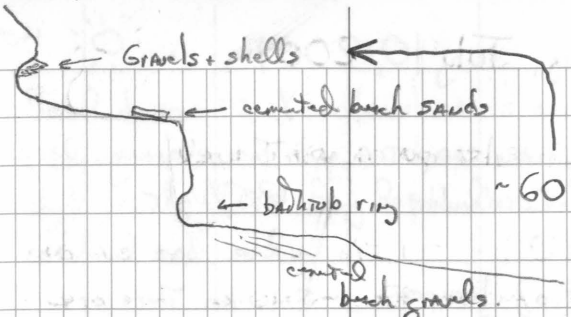
Continuing east on coastal road.

CRETE 08 On the divide east of our night-over in Frangocastle. - exposure of phyllite-quartzite, with a limestone conglomerate and mix-provenance (limestone + rounded qtzite) fan (?) deposit. The top 3m is a stage V-VI calcic horizon. What is the parent? A shoreline deposit, or a fan deposit.
Skaloti area
355 0251839; 3897990

· Kotsifos - Photo of this



CRETE 09 Amoudi Beach
Great exposures of the Bathtub ring and a Sangamon (?) terrace -
Sample collected → shell
355 0265008; 3895722



KOYPTANIOTHE →

KOURTALIOTIS Gorge - many caves - This stream traverses 3 limestone ranges before reaching the sea. The basin next to the sea is wide + has river terraces.

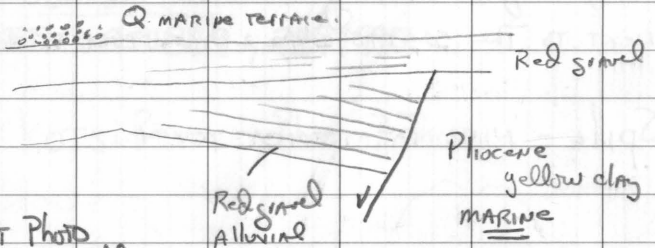
- Split - nice but tourist town.

SATURDAY, JULY 10, 2004 HOT

STAYED IN IERAPETRA for the evening.. NICE TOWN. Coral Hotel for $35/night

EAST OUT of IERAPETRA, ~ 5-10 km There are NICE uplifted beach deposits, cemented SAND + GRAVEL on white Pliocene deposits.

PILALIMATA AREA - several places of ACTIVE TECTONICS.



LAST PHOTO of 24 exp roll.

- 1st photo of 36 exp roll is of ZIROS AREA. - high MT valley in carbonate. On the way up to ZIROS, we passed high-level marine deposits & gravel.

- Road down to Xerokambios is awesome - good outcrops - clear terrace near the sea level. High level flats have a pinnacle karst with residual red soil.

CRETE 10 Xerokambios - Alluvial fan ~ 300' in Agy. unconformity with siliciclastics of Tripoliza
Then 2-3 more steps down to the sea.
There is a big gorge here... with caves.

- Gorge of the dead (Zakros) - good access, lots of caves. Scattered rounded gravel on high-level bedrock benches.

355 0428254; 3877495

RADIOCARBON SAMPLES

CRETE 1 - Paleohora Site +12m

CRETE 2 - Kalipso or Amoudi Beach
+20m BARNACLES

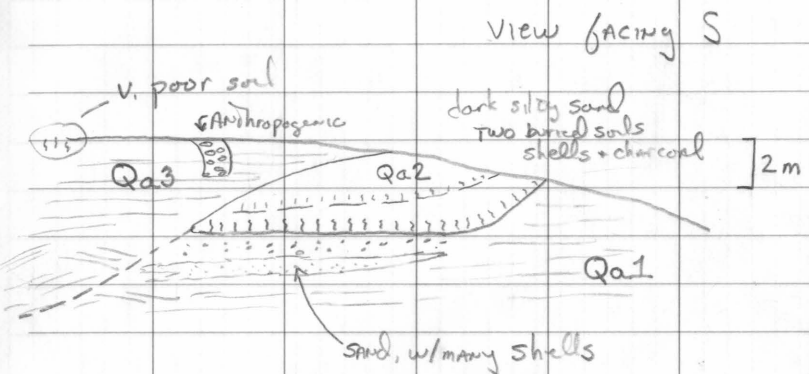
CRETE 3 - " " +20m Shell

Italy, Fall '04 Sabbatical Research

Sunday, Sept 26, 2004

In field w/ Karl Wegmann - driving a loop to see Terraces.

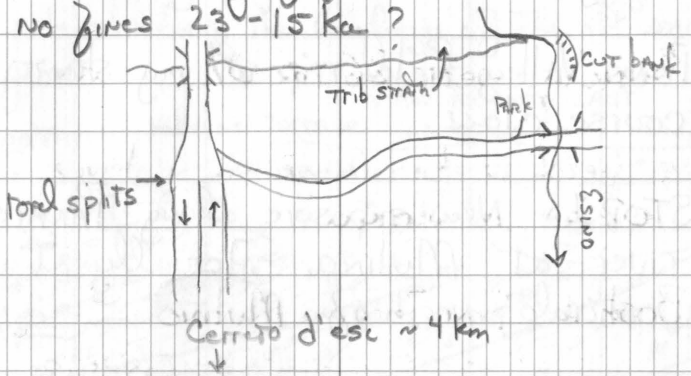
STOP 1. San Severino Marche - Potenza River; Hospital terrace exposure.



092604-01

STOP 2. Back at The Case Prezzi cut bank of The Esino site.... Impressive meandering facies buried by braided facies. Is this a climate only signal... OR a sediment supply signal? Arguing for

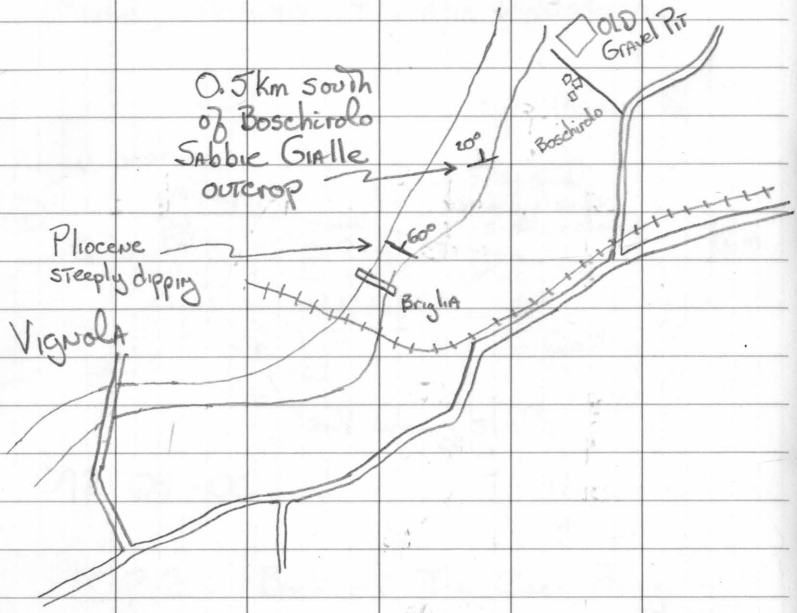
The availability of fines 36-23 ka, then no fines 23-15 ka ?



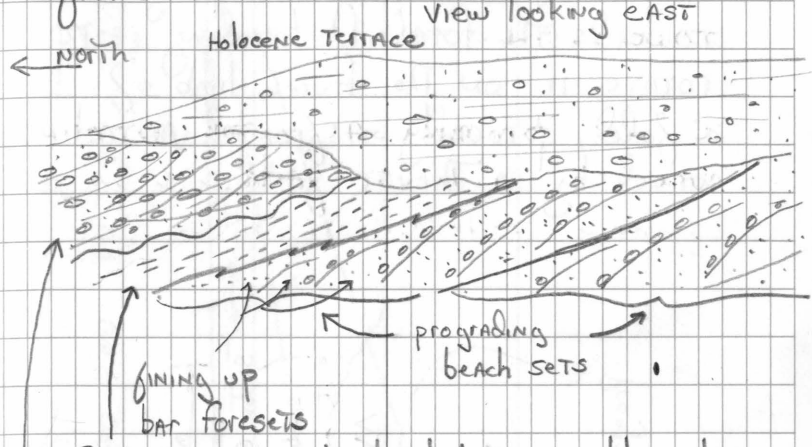
Friday, Oct 01, 2004

Reno Valley field trip w/ my short course class.

STOP 1 - New exposure along Panaro river at Mulino. - Actually at Boschirolo, north of Mulino



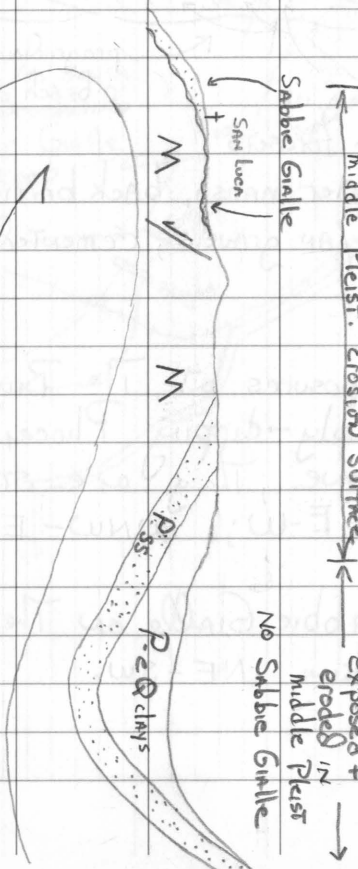
The STRATIGRAPHY at THIS SITE is key for UNDERSTANDING the GEOLOGY of the MOUNTAIN FRONT

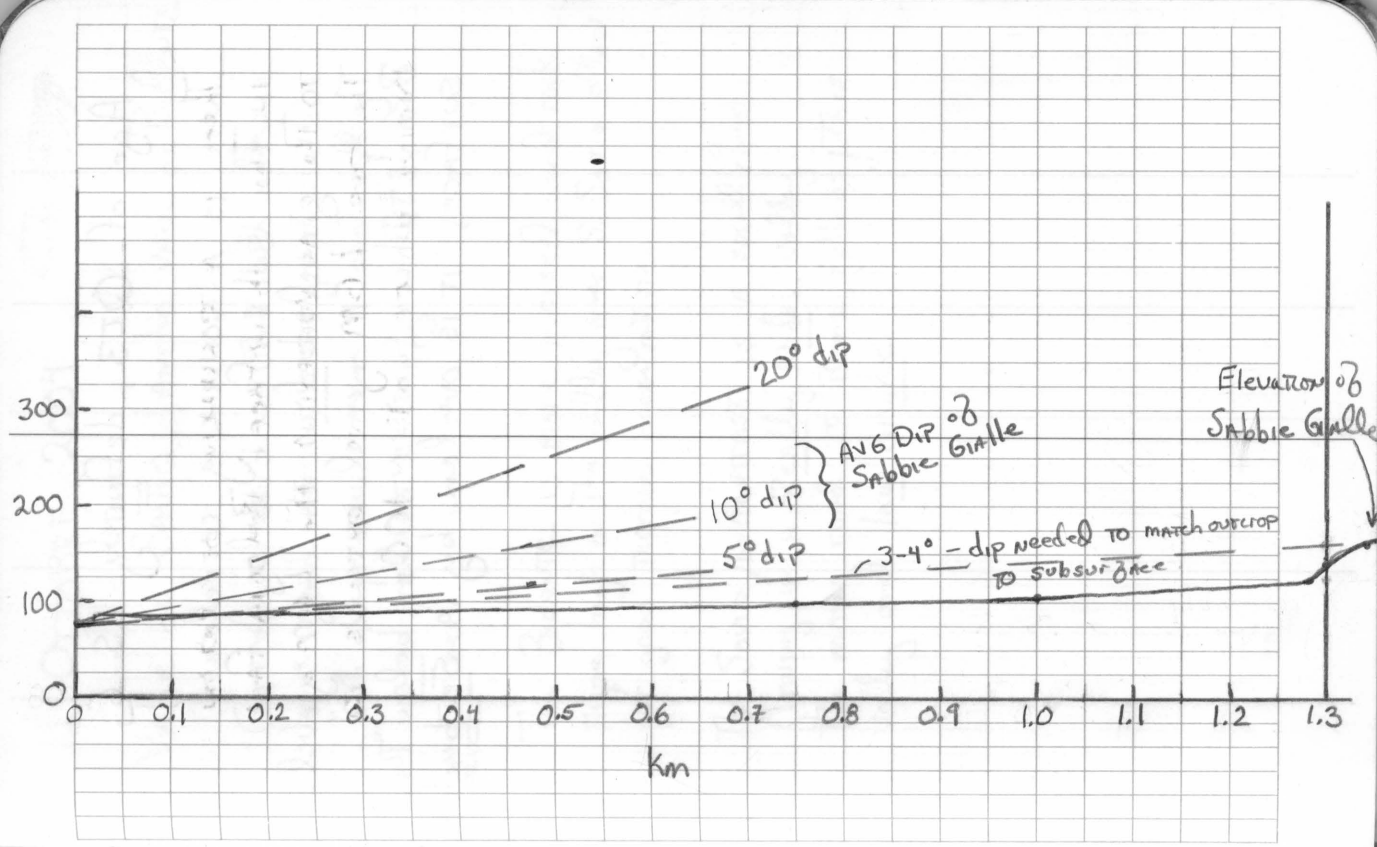


The exposures at the BIGLIA are of STEEPLY-dipping Pliocene blue clays + SANDSTONE. They are STRIKING almost E-W; WNW-ESE

The SABBIE GIALLE on the other hand IS STRIKING NE-SW.

... Seems TO me, The best + EASIEST WAY TO ACCOMODATE This progressive TOWARDS The foreland bending IS TO ROTATE IT ON The front limb of a fold, probably A frontal ANTICLINE cored by A THRUST FAULT.




20° dip
10° dip
5° dip
AVG Dip of Sabbie Gialle
3-4° - dip needed to match outcrop to subsurface
Elevation of Sabbie Gialle
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
km

Age of QT3, definitely I.S. 6,

There is a convincing correlation in the subsurface Bologna fan to the gravel below the LGM gravel. The pre LGM gravel extends to Rimini where, at ~100m below the surface, it is overlain by a 5e beach!

11 OTTOBRE, 2004

VALLE di SAVIO, ANCHE VALLE di BIDENTE

- General impression is that both valleys have good terrace stratigraphies - both in particular have a mid-valley bench - almost certainly a QT3, 156 Terrace.

The Bidente is more incised, and rock type high in the valley near S. Sofia allow for good terrace preservation.

The Savio, in contrast is a small river flowing in a Really Wide valley. The main road to Rome follows this valley and low divide

12 OTTOBRE 2004

cold

Servizio Cartografico con Paolo Severi

13 Ottobre 2004

Working in the upper watershed divide btwn the Reno & Panaro -

- Commune di Zocca -
  we tried a watertower on the hill above town - not a good site

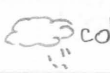
- Next: Parco Regionale Sassi di Roccamalatina
  Sasso della Croce (567m), accessed from Rocca di Sopra is a fantastic site; we are going to install a monument here
  pt. 101304-01 N 44.38730°
  E 10.94792°

- There is another site - Sasso di Sant'Andrea, in the Commune di Zocca; east of Sassi di Roccamalatina. Probably good, but we have not checked it out.

* Nice restaurant in Samone = Da Teodoro

- Mt. La Rocca at Badolo
  We will try to make a site here
  pt 101304-01 | 44.36610°N
  011.27388°E

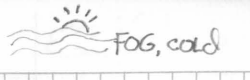
14 Ottobre 2004



Gypsum Park site: Quarry 03
Gianni Saporito

1GHDN-01

15 OTTOBRE 2004



18 OTTOBRE, 2004

- moved The FRASSASSI SITE
  101804-01 43.39434 N
  012.95951 E

TO The CINGOLI SITE
  101804-02 43.39558°N
  013.14502°E

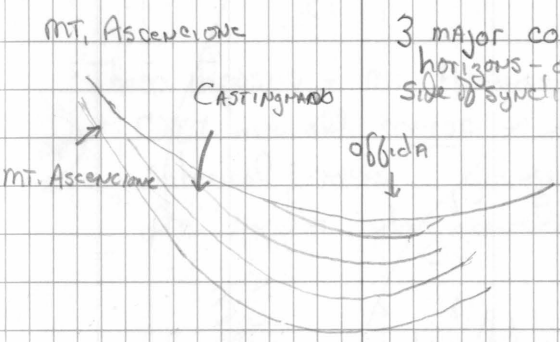
- The CINGOLI SITE IS at The RISTORANTE "LA PIGNEROSO" - FRANCO ZANNINI "IL DENNATO."

11 November 2004

Mt. Ascencione w/ Mauro

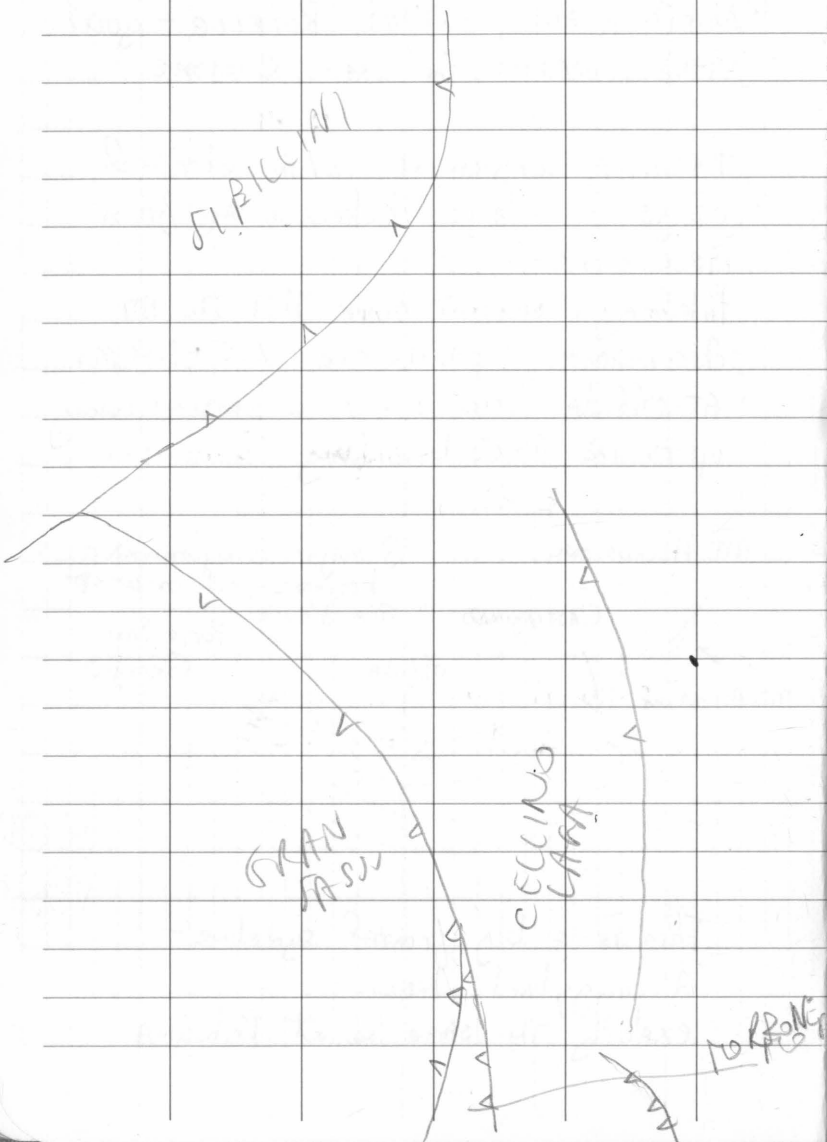
- North flank, out of Rotella - good view towards the sea - Cuestas

400 m of conglomerate w/ interbedded clays - clays thicken away from Ascencione
Paleomag + biostrat argue that the Mt. Ascencione deposits are 2.5 - 1.8 Ma.
- At Offida - there is a nice section leading up to the P-Q boundary



This is a big frontal syncline -
A piggyback basin -
exactly the same as at Bologna

A Nice Thesis from Siena Mys
This all out - Alessandro Pighini '97



MT. ASCENSIONE deposits are:

- coarse, debris flow, fluvial, + beach facies
- fining-up + coarsening-up beds
- similar to CALABRIAN - Crete fans.
- much reworked LAGA BASIN siliciclastics
- much Mesozoic L.S. + cherts.
- maximum clast size ~ 40cm, AVG ~ 6cm.

- OFFIDA - section is well exposed below the town and church.

- RIPATRANSONE - highest "Sicilian" deposits in MARCHE Region

- These deposits + MT. ASCENSIONE gravels + QT1 are all coarse + well rounded, spherical gravels ... younger terrace are angular, platy gravels

15 Novembre 2004

At INGV w/ Paco Burrato

- Annali di Geofisica V. 43 N. 4 2000
- Regione Lombardia - Aquifer Maps.
- There are Wheeler Ridge -type Anticlines on the flank of the Alps - Veneto & Friuli
- There is a program for calculating displacement from a given fault or earthquake.
- Slip rates of 1,5 mm/y are possible for the Mirandola fault (Ferrara ridge) over the past 600-800 ka. There is a seismic profile showing offset of the Sabbie Gialle. - Donatella ... student of Barchi
- There is a nice doctoral study that argues for a histone eq swarm on the PRF at Bologna - it starts in the west and moves east - 17th - 18th century.

Andrea Rovida - Milano Albiquoca.

he will be finished in February.

- Historic seismicity STOPS at Ancona.

LIDAR

- The Po Plain map is a SELCA production
- Luigi Improta - INGV shallow seismic specialist
  GRL article on his typical methodology.

  # 7-6000 / km - privato
  meno per INGV - Vibrosis at Napoli

- Fiume Cesano - la Maestà
  13.175126, 43.743322
  A nice outcrop of stage 5e? gravels behind a soccer field.
  Firamento
  It has a lagoonal a fluvial microfauna in it.

- Elisabetta d'Anastasio - doctoral student with relevelling data.

Italian Maps

1:100,000	Geographic lat-long UTM mm + Greenwich 12° 27' 08" ? difference
1: 250,000	DEM, UTM/Geographic
1: 25,000	Geographic + UTM
1: 10,000	Mappa e DEM Gauss-Boaga like UTM-Km .... There might be a program to transform.

Nov. 19 2004

Olivia Nesci
Daniele Savelli] Metauro basin

① Fano - Rosciano - fault exposure in gravel
- The bedrock - gravel exposure is stepped
- fault trends NW, cuts a 2nd order.

② 1st order terrace - IS 12 - lots of fine stuff - like QT1 in Reno. 20m of it.

③ Cimitero Sittungania 1st order terrace gravel in place - all beat up - even the Cherts - Near Saltara.

④ Calcinelli - Gravel pit -
we collected a sample. 111904-3

⑤ West of Fossombrone - west of the tunnel, on white Rd towards S. Gervasio.
2nd order, with a nice 1st order landform above & across the valley.
Sedimentology of deposit shows trib influence

A nearby (west) steep dirt road takes you up to QT1 - nice deposit of weathered clasts.

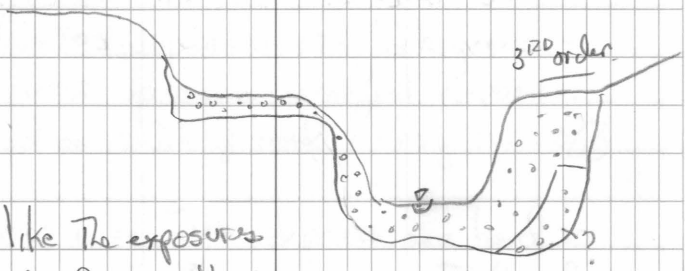
⑥ San Lazaro - strath terrace, covered by colluvium. The terrace is narrow and on river right. Holocene

⑦ Bridge at San Lazaro - an impressive 30m deep gorge. Marmite de ciganite. It is carved below Holocene strath of terrace of stop 6. The Dam here reveals a second gorge of similar dimensions, ~ 200m north... completely buried.

⑧ Excavation at Furlo - west side of gorge on road up to by quarry - Park entrance. - QT1? gravels atop a strath, cemented, covered by l. Pleist. debris. Possible cosmogenic site.

111904-06

(9) Caglí - at the main bridge on the west side of town - a trail leads down to a big fill exposure



like the exposures at Cerreto d'esi

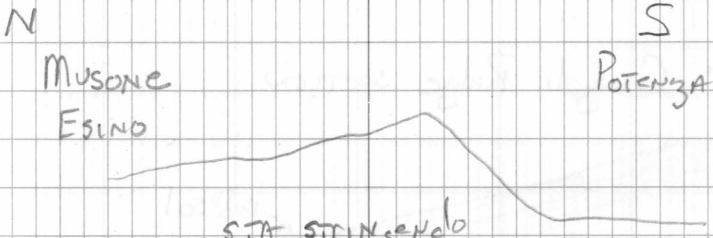
Dec 02, 2004 Thursday — Nebbia

Field work in Musone w/ Karl - A field trip to highlight his work.

- Headwaters, upstream of Chiganno - furthest upstream stratified deposits. field on south of road - easy turnoff

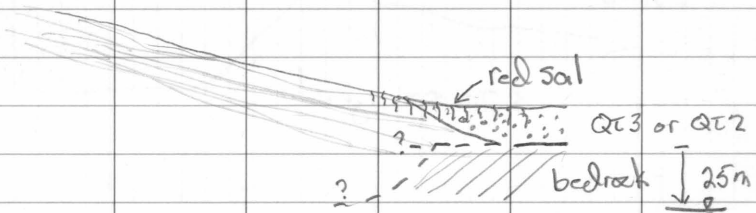
Facies wise, These deposits are hard to characterize - They are a mix of fluvial - hillslope

Minimum thickness of ~10 m. Bedrock is exposed on one side of valley. - seems that channel has been pushed by a tributary fan.



- Main road in front of Chigiano 2nd order terrace - interbedded lava-sourced debris flows within nice stratified gravel. The front and side of this deposits are eroded much more than QT3

- Cingoli Ridge section

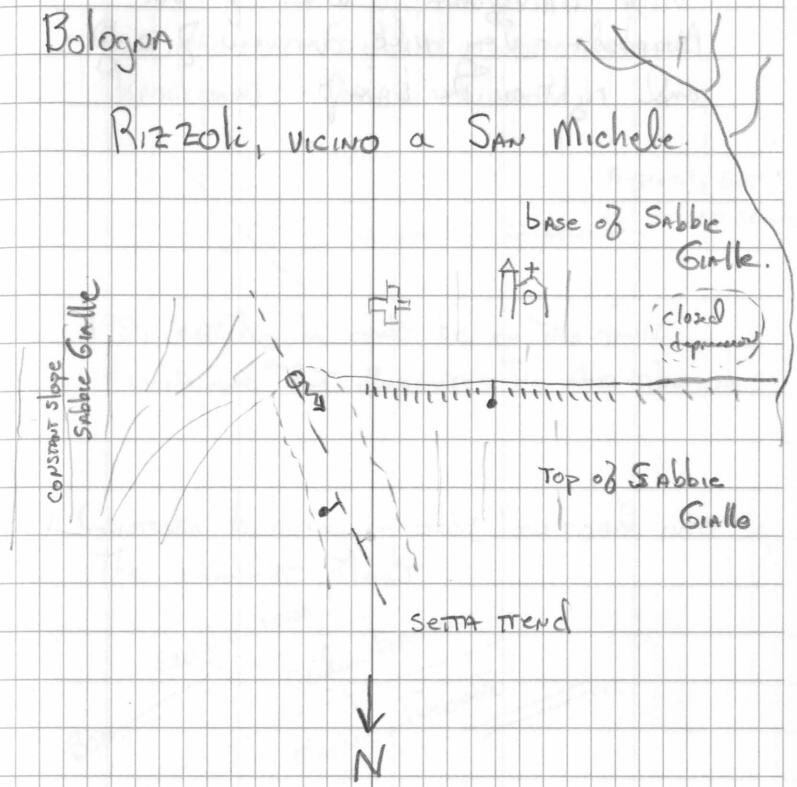


- Downstream of Cingoli Ridge → big quarry at 120204-03 sampled for snails + wood at 2 levels. Definitely braided over meandering facies. Casa Robisse.

14 Dicembre, 2004 cool

Bologna

Rizzoli, vicino a San Michele



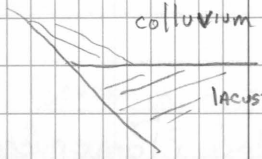
- un affiramento - Via bel Umbra, behind a private hospital
- Villa Aldini - on high hill west of Via Mamossa - on conglomerate of Sabbie Gialle - 212 m high.

Also called Inst. Giovanni XXIII

- Villa Barugziana - west of Via Mammossa - very nice overview of city and right on the scarp.

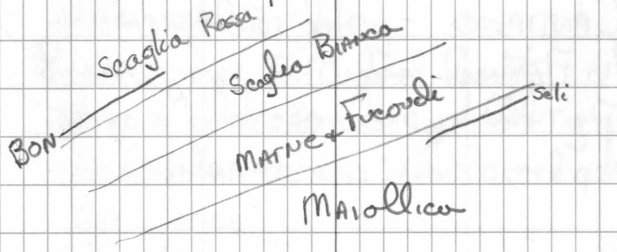
03/06/05 cold/windy

- Cimitero di Gubbio - normal fault, knickpoint, Marne + Fucoidi



1984 earthquake could be on this fault....
it is the one that illuminates the Anti-Tiburina.

- Contessa highway - old, low road into the cement plant



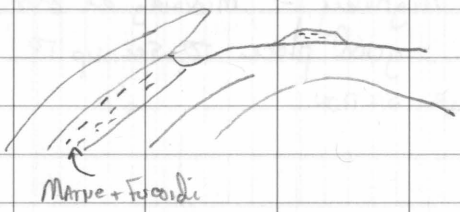
- Contessa highway - midway at old bridge - good place to see up to Miocene section.

- CONTESSA bed - flute casts are WNW + mineralogy shows Ligurian clasts provenance below CONTESSA bed, flute casts are NNW, no Ligurian.

- Gola dei Focecchiae Ponteruccole. VIA FLAMINIA - side of the road - disharmonic faulting? Shear zone of shortening in the limb of the M. Cucco Anticline. - chevron folds

- CANTIANO - old road parallely VIA FLAMINIA and that swings around the old, ruined castel - great exposure of an open Anticline.

- Ponte Romano - VIA Flaminia - old road From CANTIANO TO Cagli ; MT. PETTANO



A full section is present here!

The Burano well is located here -2500m depth.

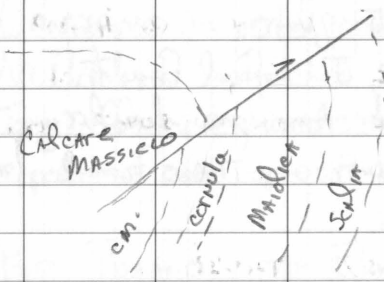
- S. Geronzio exit off of old Via Flaminia. folds in Scaglia Variegata.
- Ristorante La Rocchetta, just 1km towards Cagli from S. Geronzio. Overview from Restaurant Parking lot is Scaglia Rossa Thrust over Scaglia Cinera.
- Furlo cement quarry evidence for J normal fault Also a good Ammonite locality - Rosso Ammonitico, transitional basin to high facies.

March 07, 2005 cold

Camerino - Sibillini area

Gorge of Potenza R. where it cuts through U-M ridge. Pioraco. There is an overturned limb of a fold here, cut by a small thrust fault. The Apennines here, as in the north near Mt. Nerone, appear to be a fold, not fold + thrust belt.

Looking North



MARCH 08, 2005 — cold

- Spoleto, with FAUSTO. We have walked the TRAIL from the high ACQUEDUCT TO TORRE del PONTE, ~ 2 km OUT TO a THRUST FAULT THAT PLACES CALCARE MASSICIO over SCAGLIA ROSSA.

- VAL NERINA, TOWARDS TERNI, from Spoleto - little CUTE TOWN of Schioppo.

  Schioppo = SPARO = SCOPPIO ↓ schiopu

  Ho FATTO UN chioppo = SONO CADUTO

The FAULT here is clearly a THRUST PLACING JURASSIC up against EOCENE, latest MOTION is complicated - dip, STRIKE, + oblique slip.

- DUNAROBBA fossil forest

- Pliocene BASIN + possibility of PALEOELEVATION, PALEOALTIMITRY

  TIBER BASIN lake(s)

modern gorge of the Tevere

March 09 2005

Pisa, Alpi Apuane

Pietrasanta - Tr, metaconglomerates + rift cont. sequence

↓

Vallecchia - "Basement" E-D schists w/ Hercynian + Alpine deformation

↓

Seravezza

↓

Levigliani

↓

Big Tunnel - - - - Basement - - - - Tuscan Nappe + Marble

↓

Abandoned Quarry

↓

Towards Massa + Tunnel at Divide — Marble Quarries + visita to ocean

↓

Arni — meta sediments, schist + phyllite in Tuscan Nappe.

↓

CAMPACCIO

↓

ISOLASANTA

↓

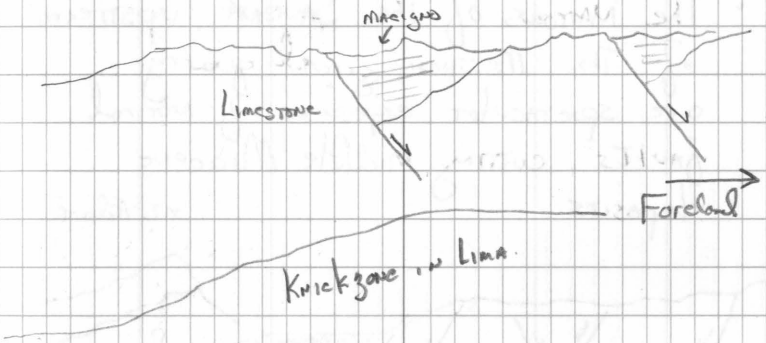
CAPRICCHIA

↓

BACK TO MAIN ROAD
OUT TO CASTELNUOVO

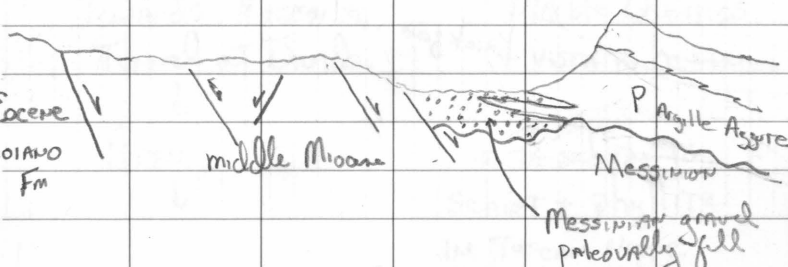
Shear Zone, Breccia to Fault ... Then possibly out to MACIGNO & FR? detachment

- Along LIMA RIVER, CASOLI, just downstream exposes high angle faults in Carbonate thrust over MACIGNO



March 10, 2005 cool

- We really need to integrate our results with Vincenzo's lines
- Bennidetti et al - Taro w/ Bally cross-section
- Vincenzo's line w/ our Terraces.
- South of Mt. Adone in Savena Valley there is a giant quarry that exposes ~30-40 m of Messinian gravel, sitting unconformably on top of Messinian Marls.
- The Narrows of the Savena, upstream of the Messinian gravel quarry are spectacular exposures of normal faults, cutting middle Miocene deposits



- There are great KNICKPOINTS here... where the FAULTS CUT the channel... also the road is offset... also there is active undercutting of the slope & landslide... The road is AN engineering problem.

March 11 2005

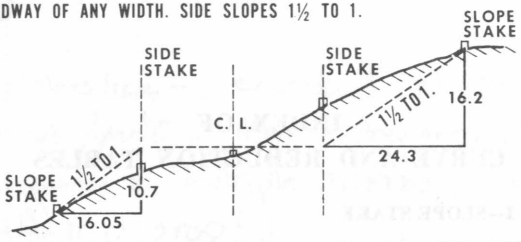
- Sillaro valley - good terrace & exposure of Sillaro line at Sassoleone
- Fontanelice - excellent exposure of Thrust fault in Marnoso Arenacea, overlying Messinian & multiple strath. Excellent field trip stop!

INDEX OF
CURVE AND REDUCTION TABLES

TABLE I. SLOPE STAKE

DISTANCES FROM SIDE STAKES FOR CROSS-SECTIONING

ROADWAY OF ANY WIDTH. SIDE SLOPES 1½ TO 1.



Cut or Fill	Distance out from Side or Shoulder Stake.										Cut or Fill
	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	
0	0 00	0 15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	0
1	1.50	1 65	1 80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	1
2	3.00	3.15	3.30	3 45	3.60	3 75	3.90	4.05	4.20	4 35	2
3	4.50	4 65	4.80	4.95	5 10	5 25	5 40	5.55	5.70	5.85	3
4	6.00	6 15	6.30	6.45	6.60	6 75	6.90	7.05	7.20	7.35	4
5	7 50	7.65	7.80	7.95	8.10	8.25	8.40	8.55	8.70	8.85	5
6	9 00	9 15	9.30	9.45	9.60	9.75	9.90	10.05	10.20	10.35	6
7	10.50	10 65	10.80	10.95	11.10	11.25	11.40	11.55	11 70	11.85	7
8	12.00	12 15	12.30	12.45	12.60	12.75	12.90	13 05	13.20	13.35	8
9	13 50	13.65	13 80	13 95	14.10	14.25	14.40	14 55	14.70	14.85	9
10	15.00	15 15	15 30	15 45	15.60	15.75	15.90	16.05	16.20	16 35	10
11	16 50	16 65	16 80	16.95	17 10	17.25	17.40	17.55	17.70	17.85	11
12	18 00	18 15	18.30	18 45	18.60	18 75	18.90	19.05	19.20	19 35	12
13	19 50	19 65	19.80	19.95	20.10	20.25	20 40	20.55	20.70	20.85	13
14	21.00	21 15	21.30	21.45	21 60	21.75	21.90	22 05	22 20	22 35	14
15	22 50	22 65	22 80	22 95	23.10	23.25	23.40	23.55	23.70	23.85	15
16	24.00	24 15	24 30	24 45	24 60	24.75	24 90	25 05	25.20	25.35	16
17	25.50	25 65	25.80	25 95	26.10	26 25	26 40	26.55	26.70	26.85	17
18	27.00	27 15	27.30	27 45	27.60	27.75	27.90	28.05	28 20	28.35	18
19	28 50	28 65	28 80	28.95	29.10	29.25	29.40	29.55	29.70	29.85	19
20	30 00	30 15	30.30	30.45	30.60	30.75	30.90	31.05	31.20	31.35	20
21	31 50	31 65	31.80	31.95	32 10	32 25	32.40	32.55	32 70	32 85	21
22	33 00	33 15	33 30	33 45	33.60	33 75	33.90	34.05	34.20	34.35	22
23	34 50	34 65	34.80	34.95	35.10	35 25	35 40	35.55	35.70	35 85	23
24	36 00	36 15	36.30	36 45	36.60	36.75	36.90	37.05	37.20	37.35	24
25	37.50	37.65	37 80	37.95	38.10	38.25	38.40	38.55	38.70	38.85	25
26	39 00	39 15	39.30	39 45	39 60	39.75	39.90	40.05	40.20	40.35	26
27	40 50	40 65	40 80	40.95	41.10	41.25	41 40	41.55	41.70	41.85	27
28	42 00	42 15	42.30	42.45	42.60	42 75	42.90	43.05	43.20	43.35	28
29	43 50	43 65	43.80	43 95	44.10	44 25	44 40	44.55	44.70	44 85	29
30	45 00	45 15	45.30	45 45	45.60	45.75	45.90	46.05	46 20	46.35	30
31	46.50	46.65	46.80	46 95	47.10	47.25	47.40	47.55	47.70	47.85	31
32	48 00	48.15	48.30	48 45	48.60	48 75	48.90	49.05	49 20	49.35	32
33	49.50	49 65	49.80	49.95	50.10	50.25	50.40	50.55	50.70	50.85	33
34	51 00	51.15	51.30	51.45	51.60	51.75	51.90	52.05	52.20	52.35	34
35	52 50	52.65	52.80	52.95	53.10	53.25	53.40	53.55	53.70	53.85	35
36	54 00	54.15	54.30	54 45	54.60	54.75	54.90	55.05	55.20	55.35	36
37	55 50	55 65	55.80	55.95	56.10	56.25	56.40	56.55	56.70	56.85	37
38	57.00	57.15	57.30	57 45	57.60	57 75	57.90	58.05	58.20	58 35	38
39	58 50	58.65	58 80	58.95	59.10	59 25	59.40	59 55	59.70	59.85	39
40	60 00	60.15	60 30	60 45	60 60	60.75	60 90	61.05	61 20	61.35	40

TABLE II. STADIA CORRECTION AND HORIZONTAL DISTANCES

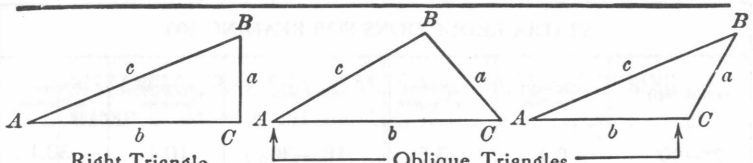
STADIA REDUCTIONS FOR READING 100

Vertical Angle	Horizontal Correction	Difference in Elevation	Vertical Angle	Horizontal Correction	Difference in Elevation
2°—00′	0.1	3.5	18°—30′	10.1	30.1
3°—00′	0.3	5.3	19°—00′	10.6	30.8
4°—00′	0.5	7.0	19°—30′	11.2	31.5
5°—00′	0.8	8.7	20°—00′	11.7	32.1
6°—00′	1.1	10.4	20°—30′	12.3	32.8
7°—00′	1.5	12.1	21°—00′	12.8	33.5
8°—00′	1.9	13.8	21°—30′	13.4	34.1
9°—00′	2.5	15.5	22°—00′	14.0	34.7
10°—00′	3.0	17.10	22°—30′	14.7	35.4
10°—30′	3.3	17.9	23°—00′	15.3	36.0
11°—00′	3.6	18.7	23°—30′	15.9	36.6
11°—30′	4.0	19.5	24°—00′	16.5	37.2
12°—00′	4.3	20.3	24°—30′	17.2	37.7
12°—30′	4.7	21.1	25°—00′	17.9	38.3
13°—00′	5.1	21.9	25°—30′	18.6	39.0
13°—30′	5.5	22.7	26°—00′	19.2	39.4
14°—00′	5.9	23.4	26°—30′	19.9	39.9
14°—30′	6.3	24.2	27°—00′	20.6	40.5
15°—00′	6.7	25.0	27°—30′	21.3	41.0
15°—30′	7.2	25.8	28°—00′	22.0	42.0
16°—00′	7.6	26.5	28°—30′	22.8	41.9
16°—30′	8.1	27.2	29°—00′	23.5	42.4
17°—00′	8.5	28.0	29°—30′	24.3	42.9
17°—30′	9.0	28.7	30°—00′	25.0	43.3
18°—00′	9.5	29.4			

Chains to Feet	
1	66
2	132
3	198
4	264
5	330
6	396
7	462
8	528
9	594
10	660

Feet to Chains	
100	1.515
200	3.030
300	4.545
400	6.060
500	7.575
600	9.090
700	10.606
800	12.121
900	13.636
1,000	15.151

TABLE III. TRIGONOMETRIC FORMULAE



Solution of Right Triangles

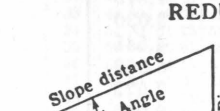
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

Given	Required	
a, b	A, B, c	$\tan A = \frac{a}{b} = \cot B$, $c = \sqrt{a^2 + b^2} = a\sqrt{1 + \frac{b^2}{a^2}}$
a, c	A, B, b	$\sin A = \frac{a}{c} = \cos B$, $b = \sqrt{(c+a)(c-a)} = c\sqrt{1 - \frac{a^2}{c^2}}$
A, a	B, b, c	$B = 90° - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$
A, b	B, a, c	$B = 90° - A$, $a = b \tan A$, $c = \frac{b}{\cos A}$
A, c	B, a, b	$B = 90° - A$, $a = c \sin A$, $b = c \cos A$,

Solution of Oblique Triangles

Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A + B = 180° - C$, $\tan \frac{1}{2}(A - B) = \frac{(a-b)\tan \frac{1}{2}(A+B)}{a+b}$, $c = \frac{a \sin C}{\sin A}$
a, b, c	A, B, C	$s = \frac{a+b+c}{2}$, $\sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}}$, $\sin \frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{ac}}$, $C = 180° - (A+B)$
a, b, c	Area	$s = \frac{a+b+c}{2}$, area $= \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	area $= \frac{b c \sin A}{2}$
A, B, C, a	Area	area $= \frac{a^2 \sin B \sin C}{2 \sin A}$

REDUCTION TO HORIZONTAL



Horizontal distance = Slope distance multiplied by the cosine of the vertical angle. Thus: slope distance = 319.4 ft. Vert. angle = 5° 10′. From Table, IV. cos 5° 10′ = .9959. Horizontal distance = 319.4 × .9959 = 318.09 ft.

Horizontal distance also = Slope distance minus slope distance times (1 − cosine of vertical angle). With the same figures as in the preceding example, the following result is obtained. Cosine 5° 10′ = .9959. 1 − .9959 = .0041. 319.4 × .0041 = 1.31. 319.4 − 1.31 = 318.09 ft.

When the rise is known, the horizontal distance is approximately:—the slope distance less the square of the rise divided by twice the slope distance. Thus: rise = 14 ft.. slope distance = 302.6 ft. Horizontal distance $= 302.6 - \frac{14 \times 14}{2 \times 302.6} = 302.6 - 0.32 = 302.28$ ft.

TABLE IV. NATURAL TRIGONOMETRICAL FUNCTIONS

Angle	Sin	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′								° ′							
0	0	0	1.	∞	∞	1.	90	8	.1392	.1405	1.0098	7.185	7.115	.99027	82
10	.0029	.0029		343.8	343.8	1.	50	10	.1421	.1435	1.0102	7.040	6.968	.98986	50
20	.0058	.0058		171.9	171.9	.99998	40	20	.1449	.1465	1.0107	6.900	6.827	.98944	40
30	.0087	.0087		114.6	114.6	.99996	30	30	.1478	.1495	1.0111	6.766	6.691	.98902	30
40	.0116	.0116	1.0001	85.94	85.94	.99993	20	40	.1507	.1524	1.0115	6.636	6.561	.98858	20
50	.0145	.0145	1.0001	68.76	68.75	.99989	10	50	.1536	.1554	1.0120	6.512	6.435	.98814	10
1	.0175	.0175	1.0002	57.30	57.29	.99985	89	9	.1564	.1584	1.0125	6.394	6.314	.98769	81
10	.0204	.0204	1.0002	49.11	49.10	.99979	50	10	.1593	.1614	1.0129	6.277	6.197	.98723	50
20	.0233	.0233	1.0003	42.98	42.96	.99973	40	20	.1622	.1644	1.0134	6.166	6.084	.98676	40
30	.0262	.0262	1.0003	38.20	38.19	.99966	30	30	.1650	.1673	1.0139	6.059	5.976	.98629	30
40	.0291	.0291	1.0004	34.38	34.37	.99958	20	40	.1679	.1703	1.0144	5.955	5.871	.98580	20
50	.0320	.0320	1.0005	31.26	31.24	.99949	10	50	.1708	.1733	1.0149	5.855	5.769	.98531	10
2	.0349	.0349	1.0006	28.65	28.64	.99939	88	10	.1736	.1763	1.0154	5.759	5.671	.98481	80
10	.0378	.0378	1.0007	26.45	26.43	.99929	50	10	.1765	.1793	1.0160	5.665	5.576	.98430	50
20	.0407	.0407	1.0008	24.56	24.54	.99917	40	20	.1794	.1823	1.0165	5.575	5.485	.98378	40
30	.0436	.0437	1.0010	22.93	22.90	.99905	30	30	.1822	.1853	1.0170	5.488	5.396	.98325	30
40	.0465	.0466	1.0011	21.49	21.47	.99892	20	40	.1851	.1883	1.0176	5.403	5.309	.98272	20
50	.0494	.0495	1.0012	20.23	20.21	.99878	10	50	.1880	.1914	1.0181	5.320	5.226	.98218	10
3	.0523	.0524	1.0014	19.11	19.08	.99863	87	11	.1908	.1944	1.0187	5.241	5.145	.98163	79
10	.0552	.0553	1.0015	18.10	18.07	.99847	50	10	.1937	.1974	1.0193	5.164	5.066	.98107	50
20	.0581	.0582	1.0017	17.20	17.17	.99831	40	20	.1965	.2004	1.0199	5.089	4.989	.98050	40
30	.0610	.0612	1.0019	16.38	16.35	.99813	30	30	.1994	.2035	1.0205	5.016	4.915	.97992	30
40	.0640	.0641	1.0020	15.64	15.60	.99795	20	40	.2022	.2065	1.0211	4.945	4.843	.97934	20
50	.0669	.0670	1.0022	14.96	14.92	.99776	10	50	.2051	.2095	1.0217	4.877	4.773	.97875	10
4	.0698	.0699	1.0024	14.34	14.30	.99756	86	12	.2079	.2126	1.0223	4.810	4.705	.97815	78
10	.0727	.0729	1.0027	13.76	13.73	.99736	50	10	.2108	.2156	1.0230	4.745	4.638	.97754	50
20	.0756	.0758	1.0029	13.23	13.20	.99714	40	20	.2136	.2186	1.0236	4.682	4.574	.97692	40
30	.0785	.0787	1.0031	12.75	12.71	.99692	30	30	.2164	.2217	1.0243	4.620	4.511	.97630	30
40	.0814	.0816	1.0033	12.29	12.25	.99668	20	40	.2193	.2247	1.0249	4.560	4.449	.97566	20
50	.0843	.0846	1.0036	11.87	11.83	.99644	10	50	.2221	.2278	1.0256	4.502	4.390	.97502	10
5	.0872	.0875	1.0038	11.47	11.43	.99619	85	13	.2250	.2309	1.0263	4.445	4.331	.97437	77
10	.0901	.0904	1.0041	11.10	11.06	.99594	50	10	.2278	.2339	1.0270	4.390	4.275	.97371	50
20	.0929	.0934	1.0043	10.76	10.71	.99567	40	20	.2306	.2370	1.0277	4.336	4.219	.97304	40
30	.0958	.0963	1.0046	10.43	10.39	.99540	30	30	.2334	.2401	1.0284	4.284	4.165	.97237	30
40	.0987	.0992	1.0049	10.13	10.08	.99511	20	40	.2363	.2432	1.0291	4.232	4.113	.97169	20
50	.1016	.1022	1.0052	9.839	9.788	.99482	10	50	.2391	.2462	1.0299	4.182	4.061	.97100	10
6	.1045	.1051	1.0055	9.567	9.514	.99452	84	14	.2419	.2493	1.0306	4.133	4.011	.97030	76
10	.1074	.1080	1.0058	9.309	9.255	.99421	50	10	.2447	.2524	1.0314	4.086	3.962	.96959	50
20	.1103	.1110	1.0061	9.065	9.010	.99390	40	20	.2476	.2555	1.0321	4.039	3.914	.96887	40
30	.1132	.1139	1.0065	8.834	8.777	.99357	30	30	.2504	.2586	1.0329	3.994	3.867	.96815	30
40	.1161	.1169	1.0068	8.614	8.556	.99324	20	40	.2532	.2617	1.0337	3.949	3.821	.96742	20
50	.1190	.1198	1.0072	8.405	8.345	.99290	10	50	.2560	.2648	1.0345	3.906	3.776	.96667	10
7	.1219	.1228	1.0075	8.206	8.144	.99255	83	15	.2588	.2679	1.0353	3.864	3.732	.96593	75
10	.1248	.1257	1.0079	8.016	7.953	.99219	50	10	.2616	.2711	1.0361	3.822	3.689	.96517	50
20	.1276	.1287	1.0082	7.834	7.770	.99182	40	20	.2644	.2742	1.0369	3.782	3.647	.96440	40
30	.1305	.1317	1.0086	7.661	7.596	.99144	30	30	.2672	.2773	1.0377	3.742	3.606	.96363	30
40	.1334	.1346	1.0090	7.496	7.429	.99106	20	40	.2700	.2805	1.0386	3.703	3.566	.96285	20
50	.1363	.1376	1.0094	7.337	7.269	.99067	10	50	.2728	.2836	1.0394	3.665	3.526	.96206	10
							82								74
							° ′								° ′
	Cosin	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

TABLE IV CONTD. NATURAL TRIGONOMETRICAL FUNCTIONS

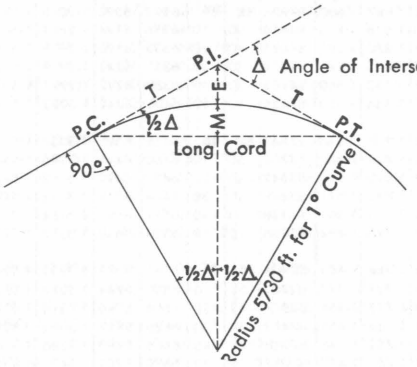
Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′								° ′							
16	.2756	.2867	1.0403	3.628	3.487	.96126	**74**	**24**	.4067	.4452	1.0946	2.459	2.246	.91355	**66**
10	.2784	.2899	1.0412	3.592	3.450	.96046	50	10	.4094	.4487	1.0961	2.443	2.229	.91236	50
20	.2812	.2931	1.0423	3.556	3.412	.95964	40	20	.4120	.4522	1.0975	2.427	2.211	.91116	40
30	.2840	.2962	1.0429	3.521	3.376	.95882	30	30	.4147	.4557	1.0989	2.411	2.194	.90996	30
40	.2868	.2994	1.0438	3.487	3.340	.95799	20	40	.4173	.4592	1.1004	2.396	2.177	.90875	20
50	.2896	.3026	1.0448	3.453	3.305	.95715	10	50	.4200	.4628	1.1019	2.381	2.161	.90753	10
17	.2924	.3057	1.0457	3.420	3.271	.95630	**73**	**25**	.4226	.4663	1.1034	2.366	2.145	.90631	**65**
10	.2952	.3089	1.0466	3.388	3.237	.95545	50	10	.4253	.4699	1.1049	2.351	2.128	.90507	50
20	.2979	.3121	1.0476	3.357	3.204	.95459	40	20	.4279	.4734	1.1064	2.337	2.112	.90383	40
30	.3007	.3153	1.0485	3.326	3.172	.95372	30	30	.4305	.4770	1.1079	2.323	2.097	.90259	30
40	.3035	.3185	1.0495	3.295	3.140	.95284	20	40	.4331	.4806	1.1095	2.309	2.081	.90133	20
50	.3062	.3217	1.0505	3.265	3.108	.95195	10	50	.4358	.4841	1.1110	2.295	2.066	.90007	10
18	.3090	.3249	1.0515	3.236	3.078	.95106	**72**	**26**	.4384	.4877	1.1126	2.281	2.050	.89879	**64**
10	.3118	.3281	1.0525	3.207	3.048	.95015	50	10	.4410	.4913	1.1142	2.268	2.035	.89752	50
20	.3145	.3314	1.0535	3.179	3.018	.94924	40	20	.4436	.4950	1.1158	2.254	2.020	.89623	40
30	.3173	.3346	1.0545	3.152	2.989	.94832	30	30	.4462	.4986	1.1174	2.241	2.006	.89493	30
40	.3201	.3378	1.0555	3.124	2.960	.94740	20	40	.4488	.5022	1.1190	2.228	1.991	.89363	20
50	.3228	.3411	1.0566	3.098	2.932	.94646	10	50	.4514	.5059	1.1207	2.215	1.977	.89232	10
19	.3256	.3443	1.0576	3.072	2.904	.94552	**71**	**27**	.4540	.5095	1.1223	2.203	1.963	.89101	**63**
10	.3283	.3476	1.0587	3.046	2.877	.94457	50	10	.4566	.5132	1.1240	2.190	1.949	.88968	50
20	.3311	.3508	1.0598	3.020	2.850	.94361	40	20	.4592	.5169	1.1257	2.178	1.935	.88835	40
30	.3338	.3541	1.0608	2.996	2.824	.94264	30	30	.4617	.5206	1.1274	2.166	1.921	.88701	30
40	.3365	.3574	1.0619	2.971	2.798	.94167	20	40	.4643	.5243	1.1291	2.154	1.907	.88566	20
50	.3393	.3607	1.0631	2.947	2.773	.94068	10	50	.4669	.5280	1.1308	2.142	1.894	.88431	10
20	.3420	.3640	1.0642	2.924	2.747	.93969	**70**	**28**	.4695	.5317	1.1326	2.130	1.881	.88295	**62**
10	.3448	.3673	1.0653	2.900	2.723	.93869	50	10	.4720	.5354	1.1343	2.119	1.868	.88158	50
20	.3475	.3706	1.0665	2.878	2.699	.93769	40	20	.4746	.5392	1.1361	2.107	1.855	.88020	40
30	.3502	.3739	1.0676	2.856	2.675	.93667	30	30	.4772	.5430	1.1379	2.096	1.842	.87882	30
40	.3529	.3772	1.0688	2.833	2.651	.93565	20	40	.4797	.5467	1.1397	2.085	1.829	.87743	20
50	.3557	.3805	1.0700	2.811	2.628	.93462	10	50	.4823	.5505	1.1415	2.073	1.816	.87603	10
21	.3584	.3839	1.0711	2.790	2.605	.93358	**69**	**29**	.4848	.5543	1.1434	2.063	1.804	.87462	**61**
10	.3611	.3872	1.0723	2.769	2.583	.93253	50	10	.4874	.5581	1.1452	2.052	1.792	.87321	50
20	.3638	.3906	1.0736	2.749	2.560	.93148	40	20	.4899	.5619	1.1471	2.041	1.780	.87178	40
30	.3665	.3939	1.0748	2.729	2.539	.93042	30	30	.4924	.5658	1.1490	2.031	1.767	.87036	30
40	.3692	.3973	1.0760	2.709	2.517	.92935	20	40	.4950	.5696	1.1509	2.020	1.756	.86892	20
50	.3719	.4006	1.0773	2.689	2.496	.92827	10	50	.4975	.5735	1.1528	2.010	1.744	.86748	10
22	.3746	.4040	1.0785	2.670	2.475	.92718	**68**	**30**	.5000	.5774	1.1547	2.000	1.732	.86603	**60**
10	.3773	.4074	1.0798	2.650	2.455	.92609	50	10	.5025	.5812	1.1566	1.990	1.720	.86457	50
20	.3800	.4108	1.0811	2.632	2.434	.92499	40	20	.5050	.5851	1.1586	1.980	1.709	.86310	40
30	.3827	.4142	1.0824	2.613	2.414	.92388	30	30	.5075	.5890	1.1606	1.970	1.698	.86163	30
40	.3854	.4176	1.0837	2.595	2.394	.92276	20	40	.5100	.5930	1.1626	1.961	1.686	.86015	20
50	.3881	.4210	1.0850	2.577	2.375	.92164	10	50	.5125	.5969	1.1646	1.951	1.675	.85866	10
23	.3907	.4245	1.0864	2.559	2.356	.92050	**67**	**31**	.5150	.6009	1.1666	1.924	1.664	.85717	**59**
10	.3934	.4279	1.0877	2.542	2.337	.91936	50	10	.5175	.6048	1.1687	1.932	1.653	.85567	50
20	.3961	.4314	1.0891	2.525	2.318	.91822	40	20	.5200	.6088	1.1707	1.923	1.643	.85416	40
30	.3987	.4348	1.0904	2.508	2.300	.91706	30	30	.5225	.6128	1.1728	1.914	1.632	.85264	30
40	.4014	.4383	1.0918	2.491	2.282	.91590	20	40	.5250	.6168	1.1749	1.905	1.621	.85112	20
50	.4041	.4417	1.0932	2.475	2.264	.91472	10	50	.5275	.6208	1.1770	1.896	1.611	.84959	10
							66								**58**
							° ′								° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

TABLE IV CONTD. NATURAL TRIGONOMETRICAL FUNCTIONS

Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan	Sec.	Cosec.	Cotg.	Cosin.	
° ′							° ′	° ′							° ′
32	.5299	.6249	1.1792	1.887	1.600	.84805	**58**	**39**	.6293	.8098	1.2868	1.589	1.235	.77715	**51**
10	.5324	.6289	1.1813	1.878	1.590	.84650	50	10	.6316	.8146	1.2898	1.583	1.228	.77531	50
20	.5348	.6330	1.1835	1.870	1.580	.84495	40	20	.6338	.8195	1.2929	1.578	1.220	.77347	40
30	.5373	.6371	1.1857	1.861	1.570	.84339	30	30	.6361	.8243	1.2959	1.572	1.213	.77162	30
40	.5398	.6412	1.1879	1.853	1.560	.84182	20	40	.6383	.8292	1.2991	1.567	1.206	.76977	20
50	.5422	.6453	1.1901	1.844	1.550	.84025	10	50	.6406	.8342	1.3022	1.561	1.199	.76791	10
33	.5446	.6494	1.1924	1.836	1.540	.83867	**57**	**40**	.6428	.8391	1.3054	1.556	1.192	.76604	**50**
10	.5471	.6536	1.1946	1.828	1.530	.83708	50	10	.6450	.8441	1.3086	1.550	1.185	.76417	50
20	.5495	.6577	1.1969	1.820	1.520	.83549	40	20	.6472	.8491	1.3118	1.545	1.178	.76229	40
30	.5519	.6619	1.1992	1.812	1.511	.83389	30	30	.6494	.8541	1.3151	1.540	1.171	.76041	30
40	.5544	.6661	1.2015	1.804	1.501	.83228	20	40	.6517	.8591	1.3184	1.535	1.164	.75851	20
50	.5568	.6703	1.2039	1.796	1.492	.83066	10	50	.6539	.8642	1.3217	1.529	1.157	.75661	10
34	.5592	.6745	1.2062	1.788	1.483	.82904	**56**	**41**	.6561	.8693	1.3251	1.524	1.150	.75471	**49**
10	.5616	.6787	1.2086	1.781	1.473	.82741	50	10	.6583	.8744	1.3284	1.519	1.144	.75280	50
20	.5640	.6830	1.2110	1.773	1.464	.82577	40	20	.6604	.8796	1.3318	1.514	1.137	.75088	40
30	.5664	.6873	1.2134	1.766	1.455	.82413	30	30	.6626	.8847	1.3352	1.509	1.130	.74896	30
40	.5688	.6916	1.2158	1.758	1.446	.82248	20	40	.6648	.8899	1.3386	1.504	1.124	.74703	20
50	.5712	.6959	1.2183	1.751	1.437	.82082	10	50	.6670	.8952	1.3421	1.499	1.117	.74509	10
35	.5736	.7002	1.2208	1.743	1.428	.81915	**55**	**42**	.6691	.9004	1.3456	1.494	1.111	.74314	**48**
10	.5760	.7046	1.2233	1.736	1.419	.81748	50	10	.6713	.9057	1.3492	1.490	1.104	.74120	50
20	.5783	.7089	1.2258	1.729	1.411	.81580	40	20	.6734	.9110	1.3527	1.485	1.098	.73924	40
30	.5807	.7133	1.2283	1.722	1.402	.81412	30	30	.6756	.9163	1.3563	1.480	1.091	.73728	30
40	.5831	.7177	1.2309	1.715	1.393	.81242	20	40	.6777	.9217	1.3600	1.476	1.085	.73531	20
50	.5854	.7221	1.2335	1.708	1.385	.81072	10	50	.6799	.9271	1.3636	1.471	1.079	.73333	10
36	.5878	.7265	1.2361	1.701	1.376	.80902	**54**	**43**	.6820	.9325	1.3673	1.466	1.072	.73135	**47**
10	.5901	.7310	1.2387	1.695	1.368	.80730	50	10	.6841	.9380	1.3711	1.462	1.066	.72937	50
20	.5925	.7355	1.2413	1.688	1.360	.80558	40	20	.6862	.9435	1.3748	1.457	1.060	.72737	40
30	.5948	.7400	1.2440	1.681	1.351	.80386	30	30	.6884	.9490	1.3786	1.453	1.054	.72537	30
40	.5972	.7445	1.2466	1.675	1.343	.80212	20	40	.6905	.9545	1.3824	1.448	1.048	.72337	20
50	.5995	.7490	1.2494	1.668	1.335	.80038	10	50	.6926	.9601	1.3863	1.444	1.042	.72136	10
37	.6018	.7536	1.2521	1.662	1.327	.79864	**53**	**44**	.6947	.9657	1.3902	1.440	1.036	.71934	**46**
10	.6041	.7581	1.2549	1.655	1.319	.79688	50	10	.6967	.9713	1.3941	1.435	1.030	.71732	50
20	.6065	.7627	1.2577	1.649	1.311	.79512	40	20	.6988	.9770	1.3980	1.431	1.024	.71529	40
30	.6088	.7673	1.2605	1.643	1.303	.79335	30	30	.7009	.9827	1.4020	1.427	1.018	.71325	30
40	.6111	.7720	1.2633	1.636	1.295	.79158	20	40	.7030	.9884	1.4061	1.422	1.012	.71121	20
50	.6134	.7766	1.2661	1.630	1.288	.78980	10	50	.7050	.9942	1.4101	1.418	1.006	.70916	10
38	.6157	.7813	1.2690	1.624	1.280	.78801	**52**		.7071	1.	1.414	1.414	1.	.70711	**45**
10	.6180	.7860	1.2719	1.618	1.272	.78622	50								
20	.6202	.7907	1.2748	1.612	1.265	.78442	40								
30	.6225	.7954	1.2778	1.606	1.257	.78261	30								
40	.6248	.8002	1.2808	1.601	1.250	.78079	20								
50	.6271	.8050	1.2838	1.595	1.242	.77897	10								
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

CURVE TABLE

Table of Tangent and External to a 1° Curve



To find Tangent and External for curve of any other degree, divide by degree of curve and add correction found in column of corrections.

Degree of curve with a given I may be found by dividing tangent, (or external), opposite I by given tangent, (or external).

The distance from a point on the tangent to the curve is very nearly the square of the tangent length divided by twice the radius.

CURVE FORMULAS

Radius: $R = \dfrac{50}{\sin \frac{1}{2} D}$

Length of Curve: $L = 100 \dfrac{\Delta}{D}$

also $L = .0174533 \times \Delta \times R$

Degree of Curve: $D = 100 \dfrac{\Delta}{L}$

Tangent: $T = R \tan \frac{1}{2} \Delta$

Long Cord: $LC = 2R \sin \frac{1}{2} \Delta$

Middle Ordinate: $M = R\ (1 - \text{Cos}\ \frac{1}{2}\ \Delta)$

External: $E = T \tan \frac{1}{4} \Delta$

TABLE V. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=10°	I	T	E	I=20°	I	T	E	I=30°
1°	50.00	.218	+	11°	551.70	26.500	+	21°	1061.9	97.577	+
10′	58.34	.297	5° C.	10′	560.11	27.313	5° C.	10′	1070.6	99.155	5° C.
20′	66.67	.388	T	20′	568.53	28.137	T	20′	1079.2	100.75	T
30′	75.01	.491	.03	30′	576.95	28.974	.06	30′	1087 8	102.35	.10
40′	83.34	.606	E	40′	585.36	29.824	E	40′	1096.4	103.97	E
50′	91.68	.733	.001	50′	593.79	30.686	.006	50′	1105.1	105.60	.013
2°	100.01	.873		12°	602.21	31.561		22°	1113.7	107.24	
10′	108.35	1.024		10′	610.64	32.447		10′	1122.4	108.90	
20′	116.68	1.188		20′	619.07	33.347		20′	1131.0	110.57	
30′	125.02	1.364		30′	627.50	34.259		30′	1139.7	112.25	
40′	133.36	1.552		40′	635.93	35.183		40′	1148.4	113.95	
50′	141.70	1.752		50′	644.37	36.120		50′	1157.0	115.66	
3°	150.04	1.964	10° C.	13°	652.81	37.070	10° C.	23°	1165.7	117.38	10° C.
10′	158.38	2.188	T	10′	661.25	38.031	T	10′	1174.4	119.12	T
20′	166.72	2.425	.06	20′	669.70	39.006	.13	20′	1183.1	120.87	.19
30′	175.06	2.674	E	30′	678.15	39.993	E	30′	1191.8	122.63	E
40′	183.40	2.934	.003	40′	686.60	40.992	.011	40′	1200.5	124.41	.025
50′	191.74	3.207		50′	695.06	42.004		50′	1209.2	126.20	
4°	200.08	3.492		14°	703.51	43.029		24°	1217.9	128.00	
10′	208.43	3.790		10′	711.97	44.066		10′	1226.6	129.82	
20′	216.77	4.099		20′	720.44	45.116		20′	1235.3	131.65	
30′	225.12	4.421		30′	728.90	46.178		30′	1244.0	133.50	
40′	233.47	4.755		40′	737.37	47.253		40′	1252.8	135.35	
50′	241.81	5.100	15° C.	50′	745.85	48.341	15° C.	50′	1261.5	137.23	15° C.
5°	250.16	5.459	T	15°	754.32	49.441	T	25°	1270.2	139.11	T
10′	258.51	5.829	.09	10′	762.80	50.554	.19	10′	1279.0	141.01	.29
20′	266.86	6.211	E	20′	771.29	51.679	E	20′	1287.7	142.93	E
30′	275.21	6.606	.004	30′	779.77	52.818	.017	30′	1296.5	144.85	.038
40′	283.57	7.013		40′	788.26	53.969		40′	1305.3	146.79	
50′	291.92	7.432		50′	796.75	55.132		50′	1314.0	148.75	
6°	300.28	7.863		16°	805.25	56.309		26°	1322.8	150.71	
10′	308.64	8.307		10′	813.75	57.498		10′	1331.6	152.69	
20′	316.99	8.762		20′	822.25	58.699		20′	1340.4	154.69	
30′	325.35	9.230		30′	830.76	59.914		30′	1349.2	156.70	
40′	333.71	9.710	20° C.	40′	839.27	61.141	20° C.	40′	1358.0	158.72	20° C.
50′	342.08	10.202	T	50′	847.78	62.381	T	50′	1366.8	160.76	T
7°	350.44	10.707	.13	17°	856.30	63.634	.26	27°	1375.6	162.81	.39
10′	358.81	11.224	E	10′	864.82	64.900	E	10′	1384.4	164.86	E
20′	367.17	11.753	.006	20′	873.35	66.178	.022	20′	1393.2	166.95	.051
30′	375.54	12.294		30′	881.88	67.470		30′	1402.0	169.04	
40′	383.91	12.847		40′	890.41	68.774		40′	1410.9	171.15	
50′	392.28	13.413		50′	898.95	70.091		50′	1419.7	173.27	
8°	400.66	13.991		18°	907.49	71.421		28°	1428.6	175.41	
10′	409.03	14.582		10′	916.03	72.764		10′	1437.4	177.55	
20′	417.41	15.184	25° C.	20′	924.58	74.119	25° C.	20′	1446.3	179.72	25° C.
30′	425.79	15.799	T	30′	933.13	75.488	T	30′	1455.1	181.89	T
40′	434.17	16.426	.16	40′	941.69	76.869	.32	40′	1464.0	184.08	.49
50′	442.55	17.065	E	50′	950.25	78.264	E	50′	1472.9	186.29	E
9°	450.93	17.717	.007	19°	958.81	79.671	.028	29°	1481.8	188.51	.065
10′	459.32	18.381		10′	967.38	81.092		10′	1490.7	190.74	
20′	467.71	19.058		20′	975.96	82.525		20′	1499.6	192.99	
30′	476.10	19.746		30′	984.53	83.972		30′	1508.5	195.25	
40′	484.49	20.447		40′	993.12	85.431		40′	1517.4	197.53	
50′	492.88	21.161		50′	1001.7	86.904		50′	1526.3	199.82	
10°	501.28	21.887	30° C.	20°	1010.3	88.389	30° C.	30°	1535.3	202.12	30° C.
10′	509.68	22.624	T	10′	1018.9	89.888	T	10′	1544.2	204.44	T
20′	518.08	23.375	.19	20′	1027.5	91.399	.39	20′	1553.1	206.77	.59
30′	526.48	24.138	E	30′	1036.1	92.924	E	30′	1562.1	209.12	E
40′	534.89	24.913	.008	40′	1044.7	94.462	.034	40′	1571.0	211.48	.078
50′	543.29	25.700		50′	1053.3	96.013		50′	1580.0	213.86	

$T = R \tan \frac{1}{2}I$ $E = R \operatorname{exsec} \frac{1}{2}I$

TABLE V CONTD. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=40°	I	T	E	I=50°	I	T	E	I=60°
31°	1589.0	216.3	+	41°	2142.2	387.4	+	51°	2732.9	618.4	+
10′	1598.0	218.7	5° C.	10′	2151.7	390.7	5° C.	10′	2743.1	622.8	5° C.
20′	1606.9	221.1	T	20′	2161.2	394.1	T	20′	2753.4	627.2	T
30′	1615.9	223.5	.13	30′	2170.8	397.4	.17	30′	2763.7	631.7	.21
40′	1624.9	226.0	E	40′	2180.3	400.8	E	40′	2773.9	636.2	E
50′	1633.9	228.4	.023	50′	2189.9	404.2		50′	2784.2	640.7	
32°	1643.0	230.9		42°	2199.4	407.6	.037	52°	2794.5	645.2	.056
10′	1652.0	233.4		10′	2209.0	411.1		10′	2804.9	649.7	
20′	1661.0	235.9		20′	2218.6	414.5		20′	2815.2	654.3	
30′	1670.0	238.4		30′	2228.1	418.0		30′	2825.6	658.8	
40′	1679.1	241.0		40′	2237.7	421.4		40′	2835.9	663.4	
50′	1688.1	243.5		50′	2247.3	425.0		50′	2846.3	668.0	
33°	1697.2	246.1	10° C.	43°	2257.0	428.5	10° C.	53°	2856.7	672.7	10° C.
10′	1706.3	248.7	T	10′	2266.6	432.0	T	10′	2867.1	677.3	T
20′	1715.3	251.3	.26	20′	2276.2	435.6	.34	20′	2877.5	682.0	.42
30′	1724.4	253.9	E	30′	2285.9	439.2	E	30′	2888.0	686.7	E
40′	1733.5	256.5	.046	40′	2295.6	442.8	.075	40′	2898.4	691.4	.112
50′	1742.6	259.1		50′	2305.2	446.4		50′	2908.9	696.1	
34°	1751.7	261.8		44°	2314.9	450.0		54°	2919.4	700.9	
10′	1760.8	264.5		10′	2324.6	453.6		10′	2929.9	705.7	
20′	1770.0	267.2		20′	2334.3	457.3		20′	2940.4	710.5	
30′	1779.1	269.9		30′	2344.1	461.0		30′	2951.0	715.3	
40′	1788.2	272.6		40′	2353.8	464.6		40′	2961.5	720.1	
50′	1797.4	275.3	15° C.	50′	2363.5	468.4	15° C.	50′	2972.1	725.0	15° C.
35°	1806.6	278.1	T	45°	2373.3	472.1	T	55°	2982.7	729.9	T
10′	1815.7	280.8	.40	10′	2383.1	475.8	.51	10′	2993.3	734.8	.63
20′	1824.9	283.6	E	20′	2392.8	479.6	E	20′	3003.9	739.7	E
30′	1834.1	286.4	.070	30′	2402.6	483.4	.116	30′	3014.5	744.6	.168
40′	1843.3	289.2		40′	2412.4	487.2		40′	3025.2	749.6	
50′	1852.5	292.0		50′	2422.3	491.0		50′	3035.8	754.6	
36°	1861.7	294.9		46°	2432.1	494.8		56°	3046.5	759.6	
10′	1870.9	297.7		10′	2441.9	498.7		10′	3057.2	764.6	
20′	1880.1	300.6		20′	2451.8	502.5		20′	3067.9	769.7	
30′	1889.4	303.5		30′	2461.7	506.4		30′	3078.7	774.7	20° C.
40′	1898.6	306.4	20° C.	40′	2471.5	510.3	20° C.	40′	3089.4	779.8	T
50′	1907.9	309.3	T	50′	2481.4	514.3	T	50′	3100.2	784.9	.84
37°	1917.1	312.2	.53	47°	2491.3	518.2	.68	57°	3110.9	790.1	E
10′	1926.4	315.2	E	10′	2501.2	522.2	E	10′	3121.7	795.2	.225
20′	1935.7	318.1	.093	20′	2511.2	526.1	.151	20′	3132.6	800.4	
30′	1945.0	321.1		30′	2521.1	530.1		30′	3143.4	805.6	
40′	1954.3	324.1		40′	2531.1	534.2		40′	3154.2	810.9	
50′	1963.6	327.1		50′	2541.0	538.2		50′	3165.1	816.1	
38°	1972.9	330.2		48°	2551.0	542.2		58°	3176.0	821.4	
10′	1982.2	333.2	25° C.	10′	2561.0	546.3	25° C.	10′	3186.9	826.7	25° C.
20′	1991.5	336.3	T	20′	2571.0	550.4	T	20′	3197.8	832.0	T
30′	2000.9	339.3	.67	30′	2581.0	554.5	.85	30′	3208.8	837.3	1.05
40′	2010.2	342.4	E	40′	2591.0	558.6	E	40′	3219.7	842.7	E
50′	2019.6	345.5	.117	50′	2601.1	562.8		50′	3230.7	848.1	
39°	2029.0	348.6		49°	2611.2	566.9	.189	59°	3241.7	853.5	.283
10′	2038.4	351.8		10′	2621.2	571.1		10′	3252.7	858.9	
20′	2047.8	354.9		20′	2631.3	575.3		20′	3263.7	864.3	
30′	2057.2	358.1		30′	2641.4	579.5		30′	3274.8	869.8	
40′	2066.6	361.3		40′	2651.5	583.8		40′	3285.8	875.3	
50′	2076.0	364.5		50′	2661.6	588.0		50′	3296.9	880.8	
40°	2085.4	367.7	30° C.	50°	2671.8	592.3	30° C.	60°	3308.0	886.4	30° C.
10′	2094.9	371.0	T	10′	2681.9	596.6	T	10′	3319.1	892.0	T
20′	2104.3	374.2	.80	20′	2692.1	600.9	1.02	20′	3330.3	897.5	1.27
30′	2113.8	377.5	E	30′	2702.3	605.3	E	30′	3341.4	903.2	E
40′	2123.3	380.8	.141	40′	2712.5	609.6	.227	40′	3352.6	908.8	.340
50′	2132.7	384.1		50′	2722.7	614.0		50′	3363.8	914.5	

$T = R \tan \frac{1}{2}I$ $E = R \operatorname{exsec} \frac{1}{2}I$

TABLE V CONTD. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=70°	I	T	E	I=80°	I	T	E	I=90°
61°	3375.0	920.2	+	71°	4086.9	1308.2	+	81°	4893.6	1805.3	+
10′	3386.3	925.9	5° C.	10′	4099.5	1315.6	5° C.	10	4908.0	1814.7	5° C.
20′	3397.5	931.6	T	20′	4112.1	1322.9	T	20′	4922.5	1824.1	T
30′	3408.8	937.3	.25	30′	4124.8	1330.3	.30	30′	4937.0	1833.6	.36
40′	3420.1	943.1	E	40′	4137.4	1337.7	E	40′	4951.5	1843.1	E
50′	3431.4	948.9	.080	50′	4150.1	1345.1	.110	50′	4966.1	1852.6	.149
62°	3442.7	954.8		72°	4162.8	1352.6		82°	4980.7	1862.2	
10′	3454.1	960.6		10′	4175.6	1360.1		10′	4995.4	1871.8	
20′	3465.4	966.5		20′	4188.5	1367.6		20′	5010.0	1881.5	
30′	3476.8	972.4		30′	4201.2	1375.2		30′	5024.8	1891.2	
40′	3488.3	978.3		40′	4214.0	1382.8		40′	5039.5	1900.9	
50′	3499.7	984.3		50′	4226.8	1390.4		50′	5054.3	1910.7	
63°	3511.1	990.2	10° C.	73°	4239.7	1398.0	10° C.	83°	5069.2	1920.5	10° C.
10′	3522.6	996.2	T	10′	4252.6	1405.7	T	10′	5084.0	1930.4	T
20′	3534.1	1002.3	.51	20′	4265.6	1413.5	.61	20′	5099.0	1940.3	.72
30′	3545.6	1008.3	E	30′	4278.5	1421.2	E	30′	5113.9	1950.3	E
40′	3557.2	1014.4	.159	40′	4291.5	1429.0	.220	40′	5128.9	1960.2	.299
50′	3568.7	1020.5		50′	4304.6	1436.8		50′	5143.9	1970.3	
64°	3580.3	1026.6		74°	4317.6	1444.6		84°	5159.0	1980.4	
10′	3591.9	1032.8		10′	4330.7	1452.5		10′	5174.1	1990.5	
20′	3603.5	1039.0		20′	4343.8	1460.4		20′	5189.3	2000.6	
30′	3615.1	1045.2		30′	4356.9	1468.4		30′	5204.4	2010.8	
40′	3626.8	1051.4		40′	4370.1	1476.4		40′	5219.7	2021.1	
50′	3638.5	1057.7	15° C.	50′	4383.3	1484.4	15° C.	50′	5234.9	2031.4	15° C.
65°	3650.2	1063.9	T	75°	4396.5	1492.4	T	85°	5250.3	2041.7	T
10′	3661.9	1070.2	.76	10′	4409.8	1500.5	.91	10′	5265.6	2052.1	1.09
20′	3673.7	1076.6	E	20′	4423.1	1508.6	E	20′	5281.0	2062.5	E
30′	3685.4	1082.9	.240	30′	4436.4	1516.7	.332	30′	5296.4	2073.0	.450
40′	3697.2	1089.3		40′	4449.7	1524.9		40′	5311.9	2083.5	
50′	3709.0	1095.7		50′	4463.1	1533.1		50′	5327.4	2094.1	
66°	3720.9	1102.2		76°	4476.5	1541.4		86°	5343.0	2104.7	
10′	3732.7	1108.6		10′	4489.9	1549.7		10′	5358.6	2115.3	
20′	3744.6	1115.1		20′	4503.4	1558.0		20′	5374.2	2126.0	
30′	3756.5	1121.7	20° C.	30′	4516.9	1566.3	20° C.	30′	5389.9	2136.7	20° C.
40′	3768.5	1128.2	T	40′	4530.4	1574.7	T	40′	5405.6	2147.5	T
50′	3780.4	1134.8	1.02	50′	4544.0	1583.1	1.22	50′	5421.4	2158.4	1.45
67°	3792.4	1141.4	E	77°	4557.6	1591.6	E	87°	5437.2	2169.2	E
10′	3804.4	1148.0	.321	10′	4571.2	1600.1	.445	10′	5453.1	2180.2	.603
20′	3816.4	1154.7		20′	4584.8	1608.6		20′	5469.0	2191.1	
30′	3828.4	1161.3		30′	4598.5	1617.1		30′	5484.9	2202.2	
40′	3840.5	1168.1		40′	4612.2	1625.7		40′	5500.9	2213.2	
50′	3852.6	1174.8		50′	4626.0	1634.4		50′	5517.0	2224.3	
68°	3864.7	1181.6		78°	4639.8	1643.0		88°	5533.1	2235.5	
10′	3876.8	1188.4		10′	4653.6	1651.7		10′	5549.2	2246.7	
20′	3889.0	1195.2	25° C.	20′	4667.4	1660.5	25° C.	20′	5565.4	2258.0	25° C.
30′	3901.2	1202.0	T	30′	4681.3	1669.2	T	30′	5581.6	2269.3	T
40′	3913.4	1208.9	1.28	40′	4695.2	1678.1	1.53	40′	5597.8	2280.6	1.83
50′	3925.6	1215.8	E	50′	4709.2	1686.9	E	50′	5614.2	2292.0	E
69°	3937.9	1222.7	.403	79°	4723.2	1695.8	.558	89°	5630.5	2303.5	.756
10′	3950.2	1229.7		10′	4737.2	1704.7		10′	5646.9	2315.0	
20′	3962.5	1236.7		20′	4751.2	1713.7		20′	5663.4	2326.6	
30′	3974.8	1243.7		30′	4765.3	1722.7		30′	5679.9	2338.2	
40′	3987.2	1250.8		40′	4779.4	1731.7		40′	5696.4	2349.8	
50′	3999.5	1257.9		50′	4793.6	1740.8		50′	5713.0	2361.5	
70°	4011.9	1265.0	30° C.	80°	4807.7	1749.9	30° C.	90°	5729.7	2373.3	30° C.
10′	4024.4	1272.1	T	10′	4822.0	1759.0	T	10′	5746.3	2385.1	T
20′	4036.8	1279.3	1.54	20′	4836.2	1768.2	1.84	20′	5763.1	2397.0	2.20
30′	4049.3	1286.5	E	30′	4850.5	1777.4	E	30′	5779.9	2408.9	E
40′	4061.8	1293.6	.485	40′	4864.8	1786.7	.671	40′	5796.7	2420.9	.910
50′	4074.4	1300.9		50′	4879.2	1796.0		50′	5813.6	2432.9	

$T = R \tan \frac{1}{2}I$ $E = R \operatorname{exsec} \frac{1}{2}I$

TABLE V CONTD. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=100°	I	T	E	I=110°	I	T	E	I=120°
91°	5830.5	2444.9	+	101°	6950.6	3278.1	+	111°	8336.7	4386.1	+
10′	5847.5	2457.1	5° C.	10′	6971.3	3294.1	5° C.	10′	8362.7	4407.6	5° C.
20′	5864.6	2469.3	T	20′	6992.0	3310.1	T	20′	8388.9	4429.2	T
30′	5881.7	2481.5	.43	30′	7012.7	3326.1	.51	30′	8415.1	4450.9	.62
40′	5898.8	2493.8	E	40′	7033.6	3342.3	E	40′	8441.5	4472.7	E
50′	5916.0	2506.1		50′	7054.5	3358.5		50′	8468.0	4494.6	
92°	5933.2	2518.5	.200	102°	7075.5	3374.9	.268	112°	8494.6	4516.6	.360
10′	5950.5	2531.0		10′	7096.6	3391.2		10′	8521.3	4538.8	
20′	5967.9	2543.5		20′	7117.8	3407.7		20′	8548.1	4561.1	
30′	5985.3	2556.0		30′	7139.0	3424.3		30′	8575.0	4583.4	
40′	6002.7	2568.6		40′	7160.3	3440.9		40′	8602.1	4606.0	
50′	6020.2	2581.3		50′	7181.7	3457.6		50′	8629.3	4628.6	
93°	6037.8	2594.0	10° C.	103°	7203.2	3474.4	10° C.	113°	8656.6	4651.3	10° C.
10′	6055.4	2606.8	T	10′	7224.7	3491.3	T	10′	8684.0	4674.2	T
20′	6073.1	2619.7	.86	20′	7246.3	3508.2	.103	20′	8711.5	4697.2	1.25
30′	6090.8	2632.6	E	30′	7268.0	3525.2	E	30′	8739.2	4720.3	E
40′	6108.6	2645.5	.401	40′	7289.8	3542.4	.536	40′	8767.0	4743.6	.721
50′	6126.4	2658.5		50′	7311.7	3559.6		50′	8794.9	4766.9	
94°	6144.3	2671.6		104°	7333.6	3576.8		114°	8822.9	4790.4	
10′	6162.2	2684.7		10′	7355.6	3594.2		10′	8851.0	4814.1	
20′	6180.2	2697.9		20′	7377.8	3611.7		20′	8879.3	4837.8	
30′	6198.3	2711.2		30′	7399.9	3629.2		30′	8907.7	4861.7	
40′	6216.4	2724.5		40′	7422.2	3646.8		40′	8936.3	4885.7	
50′	6234.6	2737.9	15° C.	50′	7444.6	3664.5	15° C.	50′	8965.0	4909.9	15° C.
95°	6252.8	2751.3	T	105°	7467.0	3682.3	T	115°	8993.8	4934.1	T
10′	6271.1	2764.8	1.30	10′	7489.6	3700.2	1.56	10′	9022.7	4958.6	1.93
20′	6289.4	2778.3	E	20′	7512.2	3718.2	E	20′	9051.7	4983.1	E
30′	6307.9	2792.0	.604	30′	7534.9	3736.2	.806	30′	9080.9	5007.8	1.09
40′	6326.3	2805.6		40′	7557.7	3754.4		40′	9110.3	5032.6	
50′	6344.8	2819.4		50′	7580.5	3772.6		50′	9139.8	5057.6	
96°	6363.4	2833.2		106°	7603.5	3791.0		116°	9169.4	5082.7	
10′	6382.1	2847.0		10′	7626.6	3809.4		10′	9199.1	5107.9	
20′	6400.8	2861.0		20′	7649.7	3827.9		20′	9229.0	5133.3	
30′	6419.5	2875.0		30′	7672.9	3846.5		30′	9259.0	5158.8	
40′	6438.4	2889.0	20° C.	40′	7696.3	3865.2	20° C.	40′	9289.2	5184.5	20° C.
50′	6457.3	2903.1	T	50′	7719.7	3884.0	T	50′	9319.5	5210.3	T
97°	6476.2	2917.3	1.74	107°	7743.2	3902.9	2.08	117°	9349.9	5236.2	2.52
10′	6495.2	2931.6	E	10′	7766.8	3921.9	E	10′	9380.5	5262.3	E
20′	6514.3	2945.9	.809	20′	7790.5	3940.9	1.08	20′	9411.3	5288.6	1.46
30′	6533.4	2960.3		30′	7814.3	3960.1		30′	9442.2	5315.0	
40′	6552.6	2974.7		40′	7838.1	3979.4		40′	9473.2	5341.5	
50′	6571.9	2989.2		50′	7862.1	3998.7		50′	9504.4	5368.2	
98°	6591.2	3003.8		108°	7886.2	4018.2		118°	9535.7	5395.1	
10′	6610.6	3018.4		10′	7910.4	4037.8		10′	9567.2	5422.1	
20′	6630.1	3033.1	25° C.	20′	7934.6	4057.4	25° C.	20′	9598.9	5449.2	25° C.
30′	6649.6	3047.9	T	30′	7959.0	4077.2	T	30′	9630.7	5476.5	T
40′	6669.2	3062.8	2.18	40′	7983.5	4097.1	2.61	40′	9662.6	5504.0	3.16
50′	6688.8	3077.7	E	50′	8008.0	4117.0	E	50′	9694.7	5531.7	E
99°	6708.6	3092.7	1.02	109°	8032.7	4137.1	1.36	119°	9727.0	5559.4	1.83
10′	6728.4	3107.7		10′	8057.4	4157.3		10′	9759.4	5587.4	
20′	6748.2	3122.9		20′	8082.3	4177.5		20′	9792.0	5615.5	
30′	6768.1	3138.1		30′	8107.3	4197.9		30′	9824.8	5643.8	
40′	6788.1	3153.3		40′	8132.3	4218.4		40′	9857.7	5672.3	
50′	6808.2	3168.7		50′	8157.5	4239.0		50′	9890.8	5700.9	
100°	6828.3	3184.1	30° C.	110°	8182.8	4259.7	30° C.	120°	9924.0	5729.7	30° C.
10′	6848.5	3199.6	T	10′	8208.2	4280.5	T	10′	9957.5	5758.6	T
20′	6868.8	3215.1	2.62	20′	8233.7	4301.4	3.14	20′	9991.0	5787.7	3.81
30′	6889.2	3230.8	E	30′	8259.3	4322.4	E	30′	10025.0	5817.0	E
40′	6909.6	3246.5		40′	8285.0	4343.6		40′	10059.0	5846.5	
50′	6930.1	3262.3	1.22	50′	8310.8	4364.8	1.63	50′	10093.0	5876.1	2.20

$T = R \tan \frac{1}{2} I$ $E = R \operatorname{exsec} \frac{1}{2} I$

USEFUL RELATIONS

Lineal feet	$\times .00019$	=	miles
Lineal yards	$\times .0006$	=	miles
Square inches	$\times .007$	=	square feet
Square feet	$\times .111$	=	square yards
Square yards	$\times .0002067$	=	acres
Acres	$\times 4840$	=	square yards
Cubic inches	$\times .00058$	=	cubic feet
Cubic feet	$\times .03704$	=	cubic yards
Links	$\times .22$	=	yards
Links	$\times .66$	=	feet
Feet	$\times 1.5$	=	links

$360° = 21600' = 1296000''$

Radius = arc of 57.2957790°

Arc of 1° (radius = 1) = .017453292

Arc of 1′ (radius = 1) = .000290888

Arc of 1″ (radius = 1) = .000004848

Curvature of Earth's surface = about 0.7 feet in 1 mile

Curvature in feet = 0.667 (Dist. in miles)^2

Difference between arc and chord length, 0.05 feet in 11½ miles

Probable error of a single observation $= 0.6754\sqrt{\frac{\Sigma v^2}{n-1}}$

Error in chaining of 0.01 feet in 100 feet:

Due to—

1. Length of tape error of 0.01 feet
2. Alignment. One end 1.4 feet out of line
3. Sag of tape at center of 0.61 feet.
4. Temperature difference of 15°
5. Difference of pull of 15 lbs.

SQUARE MEASURE

144 sq. inches = 1 sq. ft.

9 sq. ft. = 1 sq. yard

30¼ sq. yds. = 1 sq. rd.

40 sq. rds. = 1 rood.

4 roods = 1 acre

640 acres = 1 sq. mile.

SURVEYORS' MEASURE

7.92 inches = 1 link.

25 links = 1 rod.

4 rds. = 1 chain.

10 sq. chains or 160 sq. rods = 1 acre.

640 acres = 1 sq. mile.

36 sq. miles (6 miles sq.) = 1 township.

TABLE VI. INCHES TO DECIMALS OF A FOOT

In.	0	1	2	3	4	5	6	7	8	9	10	11	In.
0	Foot	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167	0
1–32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193	1–32
1–16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219	1–16
3–32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245	3–32
1–8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271	1–8
5–32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297	5–32
3–16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323	3–16
7–32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349	7–32
1–4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.3875	.7708	.8542	.9375	1–4
9–32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401	9–32
5–16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427	5–16
11–32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453	11–32
3–8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479	3–8
13–32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505	13–32
7–16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531	7–16
15–32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557	15–32
1–2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583	1–2
17–32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609	17–32
9–16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635	9–16
19–32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661	19–32
5–8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688	5–8
21–32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714	21–32
11–16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740	11–16
23–32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766	23–32
3–4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792	3–4
25–32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818	25–32
13–16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844	13–16
27–32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870	27–32
7–8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896	7–8
29–32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922	29–32
15–16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948	15–16
31–32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974	31–32
	0	1	2	3	4	5	6	7	8	9	10	11	

TABLE VII. MINUTES IN DECIMALS OF A DEGREE

0′ 30″	.00833	10′ 30″	.17500	20′ 30″	.34167	30′ 30″	.50833	40′ 30″	.67500	50′ 30″	.84167
1 00	.01667	11 00	.18333	21 00	.35000	31 00	.51667	41 00	.68333	51 00	.85000
30	.02500	30	.19167	30	.35833	30	.52500	30	.69167	30	.85833
2 00	.03333	12 00	.20000	22 00	.36667	32 00	.53333	42 00	.70000	52 00	.86667
30	.04167	30	.20833	30	.37500	30	.54167	30	.70833	30	.87500
3 00	.05000	13 00	.21667	23 00	.38333	33 00	.55000	43 00	.71667	53 00	.88333
30	.05833	30	.22500	30	.39167	30	.55833	30	.72500	30	.89167
4 00	.06667	14 00	.23333	24 00	.40000	34 00	.56667	44 00	.73333	54 00	.90000
30	.07500	30	.24167	30	.40833	30	.57500	30	.74167	30	.90833
5 00	.08333	15 00	.25000	25 00	.41667	35 00	.58333	45 00	.75000	55 00	.91667
30	.09167	30	.25833	30	.42500	30	.59167	30	.75833	30	.92500
6 00	.10000	16 00	.26667	26 00	.43333	36 00	.60000	46 00	.76667	56 00	.93333
30	.10833	30	.27500	30	.44167	30	.60833	30	.77500	30	.94167
7 00	.11667	17 00	.28333	27 00	.45000	37 00	.61667	47 00	.78333	57 00	.95000
30	.12500	30	.29167	30	.45833	30	.62500	30	.79167	30	.95833
8 00	.13333	18 00	.30000	28 00	.46667	38 00	.63333	48 00	.80000	58 00	.96667
30	.14167	30	.30833	30	.47500	30	.64167	30	.80833	30	.97500
9 00	.15000	19 00	.31667	29 00	.48333	39 00	.65000	49 00	.81667	59 00	.98333
30	.15833	30	.32500	30	.49167	30	.65833	30	.82500	30	.99167
10 00	.16667	20 00	.33333	30 00	.500000	40 00	.66667	50 00	.83333	60 00	1.00000

TABLE VIII. MIDDLE ORDINATES OF RAILS

Length of Rail (feet)

C ° ′	R Feet	30 Inch	28 Inch	26 Inch	24 Inch	22 Inch	20 Inch	C °	R Feet	30 Inch	28 Inch	26 Inch	24 Inch	22 Inch	20 Inch
0–20	17189	.08	.07	.06	.05	.04	.03	8	716.8	1.88	1.64	1.42	1.20	1.01	.84
0–40	8594	.16	.14	.12	.10	.08	.07	9	637.3	2.12	1.84	1.60	1.35	1.14	.94
1–0	5730	.24	.20	.18	.15	.13	.10	10	573.7	2.36	2.05	1.78	1.50	1.27	1.04
1–20	4297	.31	.27	.23	.20	.17	.13	11	521.7	2.59	2.26	1.95	1.65	1.39	1.15
1–40	3438	.39	.34	.29	.25	.21	.17	12	478.3	3.83	2.47	2.15	1.81	1.54	1.26
2–0	2865	.47	.41	.35	.30	.25	.20	13	441.7	3.05	2.66	2.30	1.96	1.66	1.36
2–20	2456	.55	.48	.41	.35	.29	.23	14	410.3	3.30	2.87	2.48	2.10	1.78	1.46
2–40	2149	.63	.55	.47	.40	.33	.27	15	383.1	3.54	3.08	2.68	2.26	1.91	1.57
3–0	1910	.71	.62	.53	.45	.38	.31	16	359.3	3.76	3.28	2.83	2.40	2.04	1.67
3–20	1719	.78	.68	.59	.50	.42	.35	17	338.3	4.00	3.48	3.02	2.57	2.16	1.78
3–40	1563	.86	.75	.65	.55	.46	.38	18	319.6	4.21	3.67	3.18	2.70	2.28	1.87
4–0	1433	.94	.82	.71	.60	.50	.42	19	302.9	4.45	3.89	3.36	2.86	2.41	1.98
4–20	1323	1.02	.89	.77	.65	.55	.45	20	287.9	4.70	4.09	3.55	3.00	2.54	2.09
4–40	1228	1.10	.96	.83	.70	.59	.48	22	262.0	5.16	4.44	3.84	3.30	2.80	2.29
5	1146	1.18	1.03	.89	.75	.63	.52	24	240.5	5.64	4.92	4.20	3.59	3.04	2.50
6	955.3	1.41	1.23	1.06	.90	.76	.62	26	222.3	6.07	5.29	4.58	3.88	3.29	2.70
7	819.0	1.65	1.44	1.24	1.05	.89	.73								

TABLE IX. SHORT RADIUS CURVES

Radius Feet	Chord Feet	Central Angle	Deflection Angle	Deflection for 1 Foot
35	10	16-26	8-13	49.3
45	10	12-46	6-23	38.3
50	15	17-16	8-38	34.5
60	15	14-22	7-11	28.8
75	15	11-30	5-45	23.0
100	20	11-30	5-45	17.3
120	20	9-34	4-47	14.3
150	20	7-39	3-49	11.5
190	25	7-32	3-46	9.15
200	25	7-10	3-35	8.6
225	25	6-25	3-12	7.7
240	25	5-58	2-59	7.2
250	25	5-44	2-52	6.9
275	25	5-12	2-36	6.2
288	50	9-58	4-59	6.0
300	50	9-32	4-46	5.7
350	50	8-12	4-06	4.9
376	50	7-40	3-50	4.6
400	50	7-10	3-35	4.3
410	50	7-00	3-30	4.2

To find length of curve divide angle from P. C. to P. T. by central angle of chord, and multiply by length of chord.

TABLE X. RODS IN FEET, 10THS AND 100THS OF FEET

Rods	Feet	Rods	Feet	Rods	Feet	Rods	Feet	Rods	Feet
1	16.50	21	346.50	41	676.50	61	1006.50	81	1336.50
2	33.00	22	363.00	42	693.00	62	1023.00	82	1353.00
3	49.50	23	379.50	43	709.50	63	1039.50	83	1369.50
4	66.00	24	396.00	44	726.00	64	1056.00	84	1386.00
5	82.50	25	412.50	45	742.50	65	1072.50	85	1402.50
6	99.00	26	429.00	46	759.00	66	1089.00	86	1419.00
7	115.50	27	445.50	47	775.50	67	1105.50	87	1435.50
8	132.00	28	462.00	48	792.00	68	1122.00	88	1452.00
9	148.50	29	478.50	49	808.50	69	1138.50	89	1468.50
10	165.00	30	495.00	50	825.00	70	1155.00	90	1485.00
11	181.50	31	511.50	51	841.50	71	1171.50	91	1501.50
12	198.00	32	528.00	52	858.00	72	1188.00	92	1518.00
13	214.50	33	544.50	53	874.50	73	1204.50	93	1534.50
14	231.00	34	561.00	54	891.00	74	1221.00	94	1551.00
15	247.50	35	577.50	55	907.50	75	1237.50	95	1567.50
16	264.00	36	594.00	56	924.00	76	1254.00	96	1584.00
17	280.50	37	610.50	57	940.50	77	1270.50	97	1600.50
18	297.00	38	627.00	58	957.00	78	1287.00	98	1617.00
19	313.50	39	643.50	59	973.50	79	1303.50	99	1633.50
20	330.00	40	660.00	60	990.00	80	1320.00	100	1650.00

TABLE XI. LINKS IN FEET, 10THS AND 100THS OF FEET

Links	Feet	Links	Feet	Links	Feet	Links	Feet	Links	Feet	Links	Feet
1	0.66	18	11.88	35	23.10	52	34.32	69	45.54	86	56.76
2	1.32	19	12.54	36	23.76	53	34.98	70	46.20	87	57.42
3	1.98	20	13.20	37	24.42	54	35.64	71	46.86	88	58.08
4	2.64	21	13.86	38	25.08	55	36.30	72	47.52	89	58.74
5	3.30	22	14.52	39	25.74	56	36.96	73	48.18	90	59.40
6	3.96	23	15.18	40	26.40	57	37.62	74	48.84	91	60.06
7	4.62	24	15.84	41	27.06	58	38.28	75	49.50	92	60.72
8	5.28	25	16.50	42	27.72	59	38.94	76	50.16	93	61.38
9	5.94	26	17.16	43	28.38	60	39.60	77	50.82	94	62.04
10	6.60	27	17.82	44	29.04	61	40.26	78	51.48	95	62.70
11	7.26	28	18.48	45	29.70	62	40.92	79	52.14	96	63.36
12	7.92	29	19.14	46	30.36	63	41.58	80	52.80	97	64.02
13	8.58	30	19.80	47	31.02	64	42.24	81	53.46	98	64.68
14	9.24	31	20.46	48	31.68	65	42.90	82	54.12	99	65.34
15	9.90	32	21.12	49	32.34	66	43.56	83	54.78	100	66.00
16	10.56	33	21.78	50	33.00	67	44.22	84	55.44	101	66.66
17	11.22	34	22.44	51	33.66	68	44.88	85	56.10	102	67.32

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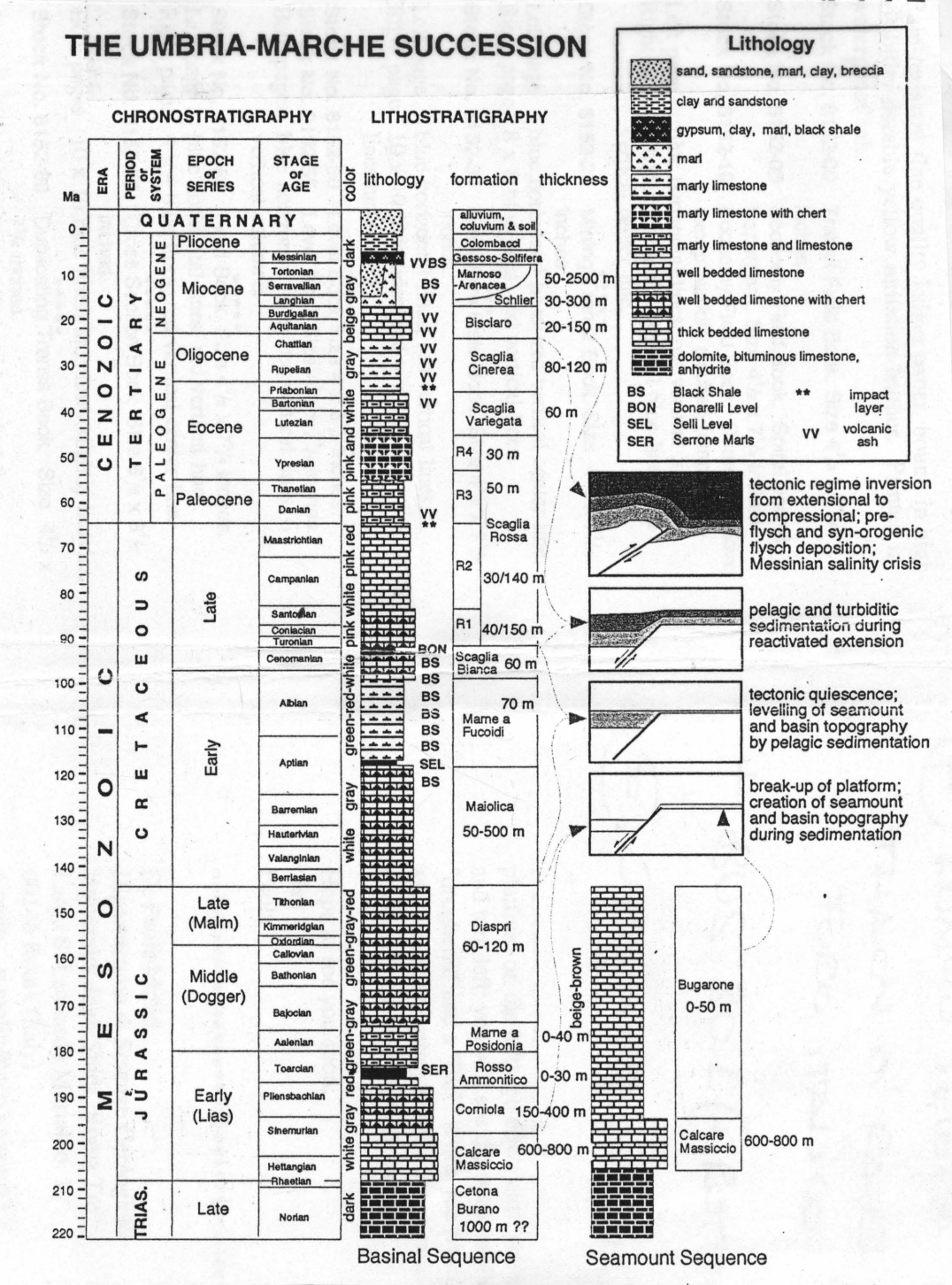

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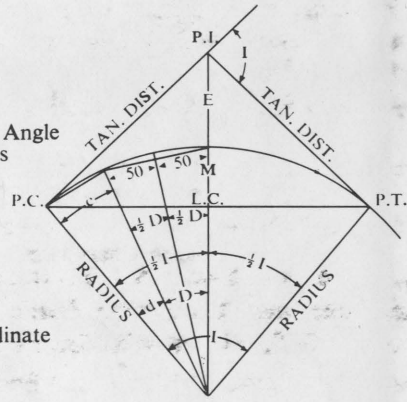
CURVE FORMULAE

D = Degree of Curve
1° = 1-Degree of Curve
2° = 2-Degree of Curve
P.C. = Point of Curve
P.T. = Point of Tangent
P.I. = Point of Intersection
I = Intersection of Angle, Angle between Two Tangents
L = Length of Curve, from P.C. to P.T.
T = Tangent Distance
E = External Distance
R = Radius
L.C. = Length of Chord
M = Length of Middle Ordinate
c = Length of Sub-Chord
d = Angle of Sub-Chord



$$R = \frac{L.C.}{2 \sin \frac{1}{2} I} \quad T = R \tan \tfrac{1}{2} I = \frac{L.C.}{2 \cos \frac{1}{2} I}$$

$$\frac{L.C.}{2} = R \sin \frac{I}{2}, \quad D\,1° = R = 5730, \quad D\,2° = \frac{5730}{2}, \quad D = \frac{5730}{R}$$

$$M = R\,(1 - \cos \tfrac{1}{2} I), \; = R - R \cos \frac{I}{2}$$

$$\frac{E + R}{R} = \sec \frac{I}{2}, \quad \frac{R - M}{R} = \cos \frac{I}{2}$$

$$c = 2\,R \sin \tfrac{1}{2} d, \quad d = \frac{c}{2\,R}$$

$$L.C. = 2\,R \sin \tfrac{1}{2} I, \quad E = R\,(\sec \tfrac{1}{2} I - 1), \; = R \sec \frac{I}{2} - R$$

Minutes in Decimals of a Degree

1′	·0167	11′	·1833	21′	·3500	31′	·5167	41′	·6833	51′	·8500
2	·0333	12	·2000	22	·3667	32	·5333	42	·7000	52	·8667
3	·0500	13	·2167	23	·3833	33	·5500	43	·7167	53	·8833
4	·0667	14	·2333	24	·4000	34	·5667	44	·7333	54	·9000
5	·0833	15	·2500	25	·4167	35	·5833	45	·7500	55	·9167
6	·1000	16	·2667	26	·4333	36	·6000	46	·7667	56	·9333
7	·1167	17	·2833	27	·4500	37	·6167	47	·7833	57	·9500
8	·1333	18	·3000	28	·4667	38	·6333	48	·8000	58	·9667
9	·1500	19	·3167	29	·4833	39	·6500	49	·8167	59	·9833
10	·1667	20	·3333	30	·5000	40	·6667	50	·8333	60	1·0000

Inches in Decimals of a Foot

$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
·0052	·0078	·0104	·0156	·0208	·0260	·0313	·0417	·0521	·0625	·0729
1	2	3	4	5	6	7	8	9	10	11
·0833	·1667	·2500	·3333	·4167	·5000	·5833	·6667	·7500	·8333	·9167

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